GOLD AND SILVER

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By Isaac A. Hourwich, Ph. D.

Gold and silver mines as treated in this chapter embrace (1) gold washings, commonly known as placers; (2) deep mines, which yield gold and silver bearing ore; and (3) ore dressing and reduction works, commonly known as mills, and operated either in connection with mines or independently. Smelters were classified at the Twelfth Census as manufacturing establishments, and were therefore excluded from the census of mines and quarries.

The precious metals being frequently associated in the ore with base metals, a proper classification of mines by the character of metals produced is attended with certain difficulties and must perforce appear artificial. Thus, from a mineralogical or metallurgical point of view, an ore assaying 50 pounds of copper to the short ton and only 1 ounce of gold is a copper ore, whereas from a commercial standpoint it is a gold ore, since the value of the 1 ounce of gold is about three times the value of the copper contained in the ore. The criterion must be determined by the object of the classification. The object of an industrial census being primarily the study of economic conditions, the classification of industries must be based upon an economic test.

The product of a mine is accordingly defined here as a gold and silver ore whenever the precious metals constitute the principal elements of its commercial value. The statistics relative to the mining of copper ores carrying small values in gold and silver are presented, together with those for other copper ores. Argentiferous iron ores, valued chiefly as fluxing material, though carrying small quantities of silver, are classed with iron ores.

This rule, like any other, is not without exceptions. The value of argentiferous lead ores follows the fluctuations in the market prices of silver and lead. The price of silver in 1902 was the lowest in many years. As a result, some mines, whose product at the prices ruling in 1901 was regarded as silver ore, realized in 1902 less for the silver than for the lead contents of their ore. Many more mines, which at the previous censuses were classed as silver mines, would now have to be considered lead mines, if judged by the relative values of the silver and lead contents of their ores. Such a classification would obviously be purely accidental and would destroy the value of all comparisons with the results of previous censuses. It was, therefore, deemed necessary to include all argentiferous lead mines among gold and silver mines.

There was, furthermore, a very numerous class of mines whose operations in 1902 were confined to development work. Any classification of such mines by the character of the ore in sight in advance of actual production is of necessity arbitrary. Though the work may at present be pursued with the prospect of finding gold and silver in paying quantities, many of these mines, in the light of past experience, will develop into copper, iron, or zinc mines. Yet the commercial nature of the investment impresses all such ventures with the character of gold and silver mines.

Census statistics of the gold and silver industry from 1860 to 1902 are summarized in the following table:

TABLE 1.—COMPARATIVE SUMMARY: 1860 TO 1902.

	1902					1889	1880[1]	1870			1860
	Producing mines.			Development work without production.	All mines.			Total.	Placer.	Deep.	
	Total.	Placer.	Deep.								
Number of mines	2,992	975	2,017	3,252	6,244	4,738	693	(2)	(2)	(2)	(2)
Number of operators	2,992	975	2,017	3,252	6,244	(2)	(2)	[3]2,377	1,994	383	[3]7,202
Salaried officials, clerks, etc.:											
Number	3,480	275	3,205	2,284	5,764	873	782	(2)	(2)	(2)	(2)
Salaries	$5,076,778	$324,418	$4,752,355	$2,335,470	$7,412,243	$1,347,373	(2)	(2)	(2)	(2)	(2)
Wage-earners:											
Average number	36,142	2,321	33,821	11,763	47,905	[4]56,434	18,415	16,908	10,441	6,467	44,316
Wages	$36,077,492	$1,818,758	$34,258,734	$11,580,684	$47,658,176	$40,412,022	$12,261,358	$8,796,525	$3,378,579	$5,417,946	$23,661,620
Contract work	$626,090	$19,953	$606,137	$1,542,771	$2,168,861	$1,421,301	(2)	(2)	(2)	(2)	(2)
Miscellaneous expenses	$5,357,529	$279,485	$5,078,044	$1,017,356	$6,374,885	$6,452,701	(2)	(2)	(2)	(2)	(2)
Cost of supplies and materials	$16,699,768	$790,986	$15,908,782	$5,075,077	$21,774,845	$18,817,739	$4,681,268	$4,064,333	$1,858,334	$2,205,999	$16,561,786
Value of product at mine:											
Total	$82,482,052	[5]$5,327,726	$77,154,326	....	$82,482,052	(2)	[6]$74,127,177	$26,452,652	$9,775,144	$16,677,508	$47,163,170
Deep	$77,154,326	....	$77,154,326	....	$77,154,326	(2)	[6]$62,030,745	$16,677,508	....	$16,677,508	(2)
Placer	$5,327,726	$5,327,726	....	....	$5,327,726	(2)	$12,096,432	$9,775,144	$9,775,144	....	(2)

[1] All statistics, except for product, for deep mines only.
[2] Not reported.
[3] Establishments.
[4] Includes 2,937 salaried employees whose salaries are included in amount paid wage-earners and are not separable therefrom.
[5] Includes an estimated production of $1,138,181 for a number of small mines for which no reports were received directly from operators.
[6] The value of the copper and lead by-product for Utah, Colorado, and Montana, $4,689,178, is added to the value of the precious metals. The product included 31,797,474 ounces of silver, which were reported at coining value. For the purpose of comparison the value has been reduced to commercial value, at the rate of $1.134 per ounce fine, which was the average for the year 1879 and 1880. The total value reported at the Tenth Census was $79,179,798.

Few reliable comparisons can be based upon the figures summarized in Table 1, as the method of collecting and presenting the data varied from census to census. The statistics for 1889 include those for mines at which only development work was done. This is probably true of the previous Census reports. The totals for 1902 were therefore summarized to show also the statistics of mines reporting development work only.

Development work.—In Table 1 is shown the extent of development work done in mines from which no production was reported. This kind of work was generally prosecuted to some extent in producing mines as well, but was always reported as a part of the ordinary mining expenses. In many cases the account was kept separately; where it was not, no separate report could be made, for the operators were unable to estimate the cost with any degree of accuracy. The total amount expended by regular producers, as far as reported, was $4,683,929. There were, moreover, a number of mines the expenditures for which largely exceeded the receipts. In some instances this may have been due to a poor grade of ore; in others to unfavorable conditions which made mining unprofitable. In most cases, however, an examination of the mine reports disclosed no difference in the grade of ore or the charges for treatment and freight as compared with other producing mines of the same district; the excess of expenditures over returns was therefore presumably due to outlays for development. All such reports were classified separately. This classification was not extended, however, to mines combined with mills, for in such cases heavy expenditures might have been incurred for mill equipment and construction work other than development. A summary of such mines, distinguished as "developing and producing," is presented in the following table, in parallel columns with data relating to regular producers, designated as "productive:"

TABLE 2.—*Comparative summary of productive and of developing and producing mines without mill connection in the United States: 1902.*

	DEEP.		PLACER.	
	Productive.	Developing and producing.	Productive.	Developing and producing.
Number of mines	700	575	818	157
Salaried officials, clerks, etc.:				
Number	653	545	190	85
Salaries	$935,181	$622,277	$220,224	$95,294
Wage-earners:				
Average number	6,634	3,851	1,718	606
Wages	$7,005,021	$3,774,122	$1,351,867	$471,611
Contract work	$198,432	$188,685	$10,422	$9,531
Work on share of product	$1,044,140	$195,289	$76,749	....
Miscellaneous expenses	$1,453,719	$468,669	$234,327	$45,158
Cost of supplies and materials	$2,760,323	$1,715,281	$588,254	$203,112
Ore sold and treated, short tons	1,326,757	228,614	....	....
Value of bullion contents:				
Gold	$18,444,330	$2,753,241	....	....
Silver	$9,014,601	$1,125,930	....	....
Other metals	$2,420,183	$468,576	....	....
Total gross value	$29,879,114	$4,347,747	....	....
Average per ton	$23	$19	....	....
Treatment charges and freight	$9,371,678	$1,679,111	....	....
Average per ton	$7	$7	....	....
Value of product at mine	$20,507,436	$2,668,636	$3,958,728	$230,817

Number of mines and operators.—These terms, whose meaning is perfectly plain in ordinary language, require a further definition when applied in a statistical sense to gold and silver mining.

There are few mines which represent one original location; most of the mining properties represent "groups" of mines, which were at some time past operated as independent undertakings, but have since been united, by purchase, lease, or otherwise, under one management. The identity of some of these mines may still be preserved; in most cases, however, their accounts are not segregated, or are only imperfectly segregated, on the books of the present owners. Thus some operators will make a separate report for each mine, while others will make one report for the group, though the difference between the properties may be in the system of bookkeeping rather than in mining conditions.

Where a mine was operated by a lessee a report was required from him. But in some mining districts it is customary to apportion the mine, in small allotments or "blocks," among a number of miners working on a royalty and designated as "lessees." The shifting character of this class of "lessees" precluded a complete canvass of their operations; in all such cases the owner of the mining property was required to make one report covering all his lessees.

In placer mining there are numerous prospectors and gold seekers moving from place to place who can not be reached by a census of mines. These miners are not included in the number of operators, but their production was ascertained from other reliable sources and is included.

A number of mines changed hands in the course of the year, and separate reports were received from each of the parties by whom the mine was successively operated. While the location and equipment of the mine remained the same, yet the character of ownership, capitalization, method of treatment of the ore, etc., in some cases had undergone a change; a combination of heterogeneous reports, made by different operators, into one, for the mines, was impracticable. Mills operated in connection with mines were by some operators reported separately and by others were included in the mine report.

In order to meet all these varying conditions it was deemed advisable to accept every individual report as a unit of enumeration, except that reduction works when connected with mines were in all cases counted as a part of the mine equipment. The number of mines and the number of operators as given in the tables are, therefore, identical. The total number of active mines, as here defined, was 2,992.

There were, furthermore, 3,252 mines which were operated in 1902 but reported no production, the work being confined to the development of the mines. This does not include mining prospects upon which "assessment work" was done, i. e., the quantity of labor required by law as a condition for holding title to the mining claim. The scope of the census of mines and quarries did not comprise a canvass of mining prospects, but a number of mining properties locally reported as active or in the development stage proved upon inquiry to be mere prospects. The number of claims which were thus reported and the number of their owners are shown in the following table, by states and territories, arranged according to the number of claims reported:

TABLE 3.—*Mining prospects upon which assessment work was done, by states and territories: 1902.*

STATE OR TERRITORY.	Number of owners.	Number of claims.
United States	5,135	5,511
California	1,219	1,322
Washington	944	995
Colorado	618	633
Oregon	422	502
Idaho	460	476
Nevada	419	439
New Mexico	403	403
Arizona	384	389
Utah	194	213
South Dakota	31	98
Wyoming	20	20
Montana	17	17
Arkansas	2	2
Alabama	1	1
North Carolina	1	1

As shown by Table 3, the attention of the prospectors was turned mainly to California, Washington, and Colorado, over one-half of the claims being located in those 3 states. The lowest rank among the Western states was held by Montana, which reported only 17 prospectors. Prospecting in the Southern states was exceptional. The total number of claims reported exceeded but little the number of owners. There were in all 43 owners reporting more than one claim each, and the total number of claims held by them was 419; the highest number of claims held by one owner was 32, and was reported from Oregon. The following table shows the distribution of owners by the number of claims held:

TABLE 4.—*Distribution of mining prospectors by number of claims held: 1902.*

NUMBER OF CLAIMS HELD BY EACH PROSPECTOR.	Number of owners.	Number of claims.
Total	5,135	5,511
1	5,092	5,092
2	2	4
3	4	12
4	8	32
5	3	15
6	2	12
7	6	42
8	7	56
9	4	36
10	2	20
11	1	11
13	1	13
14	1	14
16	2	32
20	1	20
28	1	28
30	2	60
32	1	32

The total number of mines reported as idle was 3,957. This number embraces only mines which had been previously reputed as active, and the owners of which were therefore either communicated with by mail or visited by special agents. There were doubtless many more mines which had at some time been operated, but were idle in 1902.

Character of ownership.—The majority of gold and silver mining enterprises in 1902 did not have an incorporated form of organization. A distinction is to be noted in this respect between deep mines and those in the development stage on the one hand and placers on the other hand; while about one-half of the former were operated by incorporated companies, the owners of only about one-sixth of the latter were incorporated. Another noteworthy fact is that the majority of incorporated companies were engaged exclusively in development work, whereas the majority of firms and individuals operated producing mines. It would seem, therefore, that the corporate form of ownership is more favorable to the development of modern mines. The following table presents the classification of all mines by character of ownership:

Table 5.—*All mines, classified by character of ownership: 1902.*

	Total.	Incorporated company.	Firm.	Individual.	Other form.
All mines	6,244	2,774	1,772	1,641	67
Producing mines:					
Total	2,992	1,079	923	958	32
Deep	2,017	923	575	501	18
Placer	975	156	348	457	14
Development work	3,252	1,695	849	683	25

The mines classed as "other form" included cooperative associations, mines held in joint ownership and by estates, etc.

The corporate form of ownership was especially prevalent among producing mines in Arizona, Colorado, and Utah; the owners of more than one-half of all mines in the first two and of four-fifths of those in the last-named state being incorporated companies. Among mines reporting development work only, the corporate form predominated in Arizona, Nevada, Oregon, South Dakota, Utah, Washington, and Wyoming.

The share contributed by each type of organization to the production is shown in Table 6.

Table 6.—*Producing mines, classified by character of ownership and value of product: 1902.*

Character of ownership.	Number of operators.	Value of product at mines.		
		Total.	Per cent.	Average per mine.
All mines	2,992	$82,482,052	100.0	[1] $27,021
Incorporated company	1,079	68,327,754	82.8	63,325
Firm	923	8,398,221	10.2	9,099
Individual	958	3,890,304	4.7	4,061
Other form	32	231,938	0.3	7,248
Not classified	....	1,633,835	2.0	....
Deep mines	2,017	77,154,326	100.0	[1] 38,006
Incorporated company	924	65,831,994	85.3	71,247
Firm	576	7,577,430	9.8	13,155
Individual	499	3,108,535	4.0	6,230
Other form	18	140,713	0.2	7,817
Not classified	....	495,654	0.7	....
Placer mines	975	5,327,726	100.0	[1] 4,297
Incorporated company	155	2,495,760	46.9	16,102
Firm	347	820,791	15.4	2,365
Individual	459	781,769	14.7	1,703
Other form	14	91,225	1.7	6,516
Not classified	....	1,138,181	21.3	....

[1] The "not classified" product was excluded in obtaining this average.

The preceding table shows that the corporate form of ownership, though adopted by only a little over one-third of all active operators, figured in more than four-fifths of the total output of the mines and showed the largest output per mine. Both firms and individuals belonged to the small type of producers. Other forms of organization represented but three-tenths of 1 per cent of the total output. The corporate form of ownership played a more important part in deep than in placer mining, the ownership of about one-half of all deep mines, contributing over five-sixths of the product, being that of incorporated companies, whereas the number of incorporated owners of placer mines was less than one-sixth of all placer mines, and their product was but about one-half of the total for all mines.

The following table is a summary for mines owned by incorporated and by unincorporated operators:

Table 7.—SUMMARY FOR ALL MINES, BY CHARACTER OF OWNERSHIP: 1902.

	All mines.			Deep mines.			Placer mines.		
	Total.	Incorporated.	Unincorporated.	Total.	Incorporated.	Unincorporated.	Total.	Incorporated.	Unincorporated.
Number of operators	2,992	1,079	1,913	2,017	924	1,093	975	155	820
Salaried employees:									
General officers—									
Number	437	437	....	408	408	....	29	29	....
Salaries	$810,555	$810,555	....	$772,968	$772,968	....	$37,587	$37,587	....
Other salaried employees—									
Number	3,043	2,527	516	2,797	2,326	471	246	201	45
Salaries	$4,266,218	$3,634,263	$631,955	$3,979,387	$3,386,286	$593,101	$286,831	$247,977	$38,854
Wages	$36,077,492	$30,053,790	$6,023,702	$34,254,514	$28,927,165	$5,327,349	$1,822,978	$1,126,625	$696,353
Contract work	$626,090	$521,921	$104,169	$606,137	$511,436	$94,701	$19,953	$10,485	$9,468
Work on share of product	$1,621,878	$1,164,955	$456,923	$1,545,129	$1,164,315	$380,814	$76,749	$640	$76,109
Miscellaneous expenses	$5,357,529	$4,419,537	$937,992	$5,078,044	$4,223,025	$855,019	$279,485	$196,512	$82,973
Cost of supplies and materials	$16,699,768	$14,677,977	$2,021,791	$15,908,402	$14,081,894	$1,826,508	$791,366	$596,083	$195,283
Ore sold and treated, short tons	9,542,864	8,464,023	1,078,841	9,542,864	8,464,023	1,078,841	....	....	....
Value of bullion contents:									
Gold	$62,324,093	$54,023,002	$8,301,091	$58,122,187	$51,520,030	$6,602,157	$4,201,906	$2,502,972	$1,698,934
Silver	$21,318,028	$18,563,353	$2,754,675	$21,315,793	$18,561,793	$2,754,000	$2,235	$1,560	$675
Lead	$12,259,105	$10,199,325	$2,059,780	$12,259,105	$10,199,825	$2,059,780	....	....	....
Other metals	$1,558,009	$1,300,649	$257,360	$1,557,155	$1,300,185	$256,970	$854	$464	$390
Total gross value	$97,459,235	$84,086,329	$13,372,906	$93,254,240	$81,581,338	$11,672,907	$4,204,995	$2,504,996	$1,699,999
Average value per ton	....	....	....	$10	$10	$11	....	....	....
Value of product at mine[1]	$80,848,217	$68,327,754	$12,520,463	$76,658,672	$65,831,994	$10,826,678	$4,189,545	$2,495,760	$1,693,785
Average per mine	$27,021	$63,325	$6,545	$38,006	$71,247	$9,905	$4,297	$16,102	$2,066

[1] In addition to this, $1,633,835 represents the product of mines for which the number of operators and character of ownership was not reported, $495,654 being the value produced by deep mines and $1,138,181 that by placers.

As appears from Table 7, there were approximately 3 salaried officials, clerks, etc., to an average mine of incorporated ownership, whereas only 1 mine in 4 of those owned by unincorporated operators had even 1 salaried employee; evidently at the mines of unincorporated owners the work usually done by salaried employees was performed by the operators themselves. It is worthy of note that notwithstanding the large number of mines under corporate ownership, the gold and silver mining industry remained under local control. The location of the general office of the mine may be taken as a test. The following statement shows the number of mines with general offices in the principal business or mining centers and those whose offices were located in other cities or towns, or at the mine:

Location of general offices of mines by cities: 1902.

LOCATION OF GENERAL OFFICE.	All mines.	Producing.	Development work without production.
Total	6,244	2,992	3,252
San Francisco	212	133	79
Salt Lake City	249	77	172
Denver	278	136	142
New York	136	53	83
Boston	73	34	39
All others	5,296	2,559	2,737

The number of companies with general offices in large business or mining centers was considerably short of the total number of incorporated companies. Moreover, those with offices in San Francisco, Salt Lake City, or Denver were likewise mostly local concerns whose mines were situated within the same state. This was equally true of producing and of developing mines, which fact appears from the following statement:

General offices, whether within or without the state where the mine is situated: 1902.

LOCATION OF GENERAL OFFICE.	LOCATION OF MINE.	
	Within the state.	Without the state.
San Francisco	159	53
Salt Lake City	192	57
Denver	262	16
Total	613	126
Producing	328	65
Developing	285	61

The few producing mines with eastern offices in New York and Boston had but a very small part in the gold and silver mining industry in 1902. Their aggregate product amounted to $4,122,206—5 per cent of the total for the United States—and the average product per company was only $49,000.

Capital stock of incorporated companies.—The capitalization of all incorporated gold and silver mining companies for 1902 is shown in Tables 8 and 9; the former relating to producing mines, the latter to such as reported development work only for the year 1902.

TABLE 8.—CAPITALIZATION OF INCORPORATED COMPANIES OPERATING PRODUCING MINES: 1902.

	United States.	Alabama.	Arizona.	Arkansas.	California.	Colorado.	Georgia.	Idaho.	Montana.
Number of incorporated companies	1,079	2	43	1	241	389	17	75	63
Capital stock and bonds issued	$1,024,970,643	$1,512,000	$38,874,129	$1,577,000	$160,121,081	$397,621,733	$19,082,000	$65,682,257	$70,328,440
Capital stock:									
Total authorized—									
Number of shares	773,862,231	602,000	38,951,000	20,000	94,923,578	382,343,293	17,867,500	36,962,340	29,351,580
Par value	$1,213,420,117	$3,002,000	$50,340,000	$2,000,000	$202,760,300	$440,035,417	$22,500,000	$80,404,200	$78,650,000
Total issued—									
Number of shares	611,045,694	304,000	27,501,129	15,770	71,964,616	325,997,522	15,246,520	28,616,387	21,615,899
Par value	$1,017,011,793	$1,512,000	$37,661,129	$1,577,000	$159,476,031	$392,887,833	$18,952,000	$65,348,357	$69,660,440
Dividends paid	$10,454,744	...	$404,550	...	$1,099,399	$3,689,444	...	$880,271	$248,093
Common—									
Authorized—									
Number of shares	766,744,974	602,000	36,931,000	20,000	94,333,578	380,454,435	17,867,500	36,171,940	29,293,580
Par value	$1,194,317,427	$3,002,000	$48,320,000	$2,000,000	$202,070,300	$432,642,717	$22,500,000	$76,904,200	$77,350,000
Issued—									
Number of shares	605,187,956	304,000	25,501,129	15,770	71,674,616	324,265,489	15,246,520	28,340,312	21,560,385
Par value	$1,002,055,596	$1,512,000	$35,661,129	$1,577,000	$159,186,031	$386,174,633	$18,952,000	$63,499,857	$68,609,040
Dividends paid	$10,124,711	...	$401,550	...	$1,099,399	$3,425,051	...	$880,271	$248,093
Preferred—									
Authorized—									
Number of shares	7,117,257	...	2,020,000	...	590,000	1,888,858	...	790,400	58,000
Par value	$19,102,690	...	$2,020,000	...	$690,000	$7,392,700	...	$3,500,000	$1,300,000
Issued—									
Number of shares	5,857,738	...	2,000,000	...	290,000	1,732,033	...	276,075	55,514
Par value	$14,956,197	...	$2,000,000	...	$290,000	$6,713,200	...	$1,848,500	$1,051,400
Dividends paid	$330,033	...	...	...	...	$264,393	...	...	...
Bonds:									
Authorized—									
Number	445,578	...	1,965	...	2,735	113,900	175,000	150,493	1,190
Par value	$9,839,200	...	$1,435,000	...	$785,000	$5,985,000	$175,000	$334,200	$890,000
Issued—									
Number	296,147	...	1,408	...	1,494	11,642	130,000	150,490	818
Par value	$7,958,850	...	$1,213,000	...	$645,050	$4,733,900	$130,000	$333,900	$668,000
Interest paid	$409,392	...	$78,710	...	$42,862	$211,120	$6,500	$14,000	$40,200
Assessments levied	$21,200,119	...	$160,950	...	$3,980,454	$186,015	$5,000	$54,324	$4,472

	Nevada.	New Mexico.	North Carolina.	Oregon.	South Carolina.	South Dakota.	Texas.	Utah.	Washington.	Wyoming.
Number of incorporated companies	44	39	6	48	2	23	1	67	15	3
Capital stock and bonds issued	$49,664,296	$24,472,731	$4,900,000	$25,118,821	$750,000	$54,511,396	...	$85,251,659	$20,487,100	$5,016,000
Capital stock:										
Total authorized—										
Number of shares	20,006,300	36,025,200	3,215,000	31,790,440	550,000	28,617,000	150,000	21,162,000	23,700,000	7,625,000
Par value	$55,492,400	$44,400,000	$9,250,000	$38,955,800	$550,000	$64,150,000	$150,000	$89,205,000	$23,950,000	$7,625,000
Total issued—										
Number of shares	15,235,801	17,337,531	2,156,000	18,299,761	550,000	20,836,959	...	19,668,689	20,683,110	5,016,000
Par value	$49,664,296	$24,437,731	$4,900,000	$25,118,821	$550,000	$54,511,396	...	$85,251,659	$20,487,100	$5,016,000
Dividends paid	$77,602	$69,650	...	61,669	...	$262,891	...	$3,661,175	...	...
Common—										
Authorized—										
Number of shares	19,556,300	36,005,200	3,215,000	31,790,440	400,000	27,717,000	150,000	21,162,000	23,450,001	7,625,000
Par value	$55,042,400	$44,200,000	$9,250,000	$38,955,800	$400,000	$63,250,000	$150,000	$89,205,000	$21,450,010	$7,625,000
Issued—										
Number of shares	14,935,801	17,317,531	2,156,000	18,299,761	400,000	19,954,952	...	19,668,689	20,531,001	5,016,000
Par value	$49,364,296	$24,237,731	$4,900,000	$25,118,821	$400,000	$53,629,389	...	$85,251,659	$18,966,010	$5,016,000
Dividends paid	$29,602	$69,650	...	$61,669	...	$245,251	...	$3,661,175	...	...
Preferred—										
Authorized—										
Number of shares	450,000	20,000	...	...	150,000	900,000	...	...	249,999	...
Par value	$450,000	$200,000	...	...	$150,000	$900,000	...	...	$2,499,990	...
Issued—										
Number of shares	300,000	20,000	...	...	150,000	882,007	...	...	152,109	...
Par value	$300,000	$200,000	...	...	$150,000	$882,007	...	...	$1,521,090	...
Dividends paid	$48,000	...	...	...	...	$17,640	...	...	...	...
Bonds:										
Authorized—										
Number	...	95	...	...	200	...	...	...	...	...
Par value	...	$35,000	...	...	$200,000	...	...	...	...	...
Issued—										
Number	...	95	...	...	200	...	...	...	...	...
Par value	...	$35,000	...	...	$200,000	...	...	...	...	...
Interest paid	...	...	...	...	$16,000	...	...	...	...	...
Assessments levied	$15,361,010	$98,000	...	$187,022	$21,000	$397,237	...	$554,635	$190,000	...

TABLE 9.—CAPITALIZATION OF INCORPORATED COMPANIES REPORTING DEVELOPMENT WORK WITHOUT PRODUCTION: 1902.

	United States.	Alabama.	Arizona.	California.	Colorado.	Georgia.	Idaho.	Maryland.	Montana.	Nevada.
Number of incorporated companies	1,695	1	207	146	433	2	158	1	59	61
Capital stock and bonds issued	$1,173,300,352	$2,000	$195,441,287	$89,274,203	$277,567,162	$100,000	$71,015,357	$1,000,000	$75,998,516	$39,471,081
Capital stock:										
Total authorized—										
Number of shares	1,728,938,161	40	260,138,590	64,817,596	442,718,390	5,200,000	148,919,000	40,000	95,119,000	36,775,460
Par value	$1,908,351,126	$2,000	$354,360,000	$122,763,126	$405,520,820	$6,000,000	$120,858,000	$1,000,000	$132,887,000	$54,956,680
Total issued—										
Number of shares	1,010,602,582	40	127,086,734	36,687,521	304,964,682	100,000	85,335,944	40,000	42,662,417	27,613,829
Par value	$1,171,138,461	$2,000	$193,534,907	$89,274,203	$277,467,162	$100,000	$70,912,846	$1,000,000	$75,998,516	$39,471,031
Dividends paid	$75,144	......	......	$60,000	......	......	$5,190	......	......	$954
Common—										
Authorized—										
Number of shares	1,713,435,071	40	258,288,590	64,702,596	436,797,300	5,180,000	147,066,500	40,000	95,119,000	36,259,460
Par value	$1,891,552,126	$2,000	$352,060,000	$121,613,126	$398,947,820	$5,900,000	$119,118,000	$1,000,000	$182,887,000	$53,381,680
Issued—										
Number of shares	1,001,916,256	40	126,392,397	36,672,521	301,470,486	100,000	84,283,444	40,000	42,662,417	27,270,236
Par value	$1,162,290,213	$2,000	$192,840,570	$89,124,203	$273,271,056	$100,000	$69,975,546	$1,000,000	$75,998,516	$38,995,726
Dividends paid	$69,000	......	......	$60,000	......	......	......	......	......	......
Preferred—										
Authorized—										
Number of shares	15,503,090	......	1,850,000	115,000	5,921,090	20,000	1,852,500	......	......	516,000
Par value	$16,799,000	......	$2,300,000	$1,150,000	$6,573,000	$100,000	$1,740,000	......	......	$1,575,000
Issued—										
Number of shares	8,686,326	......	694,337	15,000	3,494,196	......	1,052,500	......	......	343,593
Par value	$8,848,248	......	$694,337	$150,000	$4,196,106	......	$937,300	......	......	$475,305
Dividends paid	$6,144	......	......	......	......	......	$5,190	......	......	$954
Bonds:										
Authorized—										
Number	5,810	......	3,000	......	1,000	......	760	......	......	......
Par value	$3,340,040	......	$3,000,000	......	$100,000	......	$180,040	......	......	......
Issued—										
Number	3,540	......	1,875	......	1,000	......	315	......	......	......
Par value	$2,161,891	......	$1,906,380	......	$100,000	......	$102,511	......	......	......
Interest paid	$56,570	......	$46,132	......	$8,000	......	$2,438	......	......	......
Assessments levied	$31,657,563	......	$40,000	$1,771,230	......	......	$195,925	......	$127,500	$27,605,812

	New Jersey.	New Mexico.	North Carolina.	Oregon.	South Dakota.	Utah.	Virginia.	Washington.	Wyoming.
Number of incorporated companies	1	73	10	100	80	188	4	106	65
Capital stock and bonds issued	$400,000	$44,691,863	$4,984,500	$125,990,915	$47,167,955	$73,754,408	$2,600,550	$91,329,650	$32,510,955
Capital stock:									
Total authorized—									
Number of shares	500,000	68,543,750	4,011,120	140,231,615	133,100,600	84,971,000	3,960,000	179,830,000	60,062,000
Par value	$500,000	$69,135,000	$17,112,000	$193,450,000	$137,770,000	$92,830,000	$5,400,000	$136,317,500	$57,480,000
Total issued—									
Number of shares	400,000	39,574,499	1,189,620	70,976,019	38,092,497	66,853,561	1,160,550	133,238,641	34,626,078
Par value	$400,000	$44,638,863	$4,984,500	$125,990,915	$47,167,955	$73,754,408	$2,600,550	$91,329,650	$32,510,955
Dividends paid	......	......	......	$9,000	......	......	......	......	......
Common—									
Authorized—									
Number of shares	500,000	68,165,250	4,011,120	140,231,615	132,500,600	84,971,000	3,960,000	175,980,000	59,662,000
Par value	$500,000	$68,509,000	$17,112,000	$193,450,000	$137,170,000	$92,889,000	$5,400,000	$134,382,500	$57,280,000
Issued—									
Number of shares	400,000	39,265,799	1,189,620	70,976,019	37,562,497	66,853,561	1,160,550	131,190,641	34,426,078
Par value	$400,000	$44,181,663	$4,984,500	$125,990,915	$46,637,955	$73,754,408	$2,600,550	$90,021,650	$32,410,955
Dividends paid	......	......	......	$9,000	......	......	......	......	......
Preferred—									
Authorized—									
Number of shares	......	378,500	......	......	600,000	......	......	3,850,000	400,000
Par value	......	$626,000	......	......	$600,000	......	......	$1,935,000	$200,000
Issued—									
Number of shares	......	308,700	......	......	530,000	......	......	2,048,000	200,000
Par value	......	$457,200	......	......	$530,000	......	......	$1,308,000	$100,000
Dividends paid	......	......	......	......	......	......	......	......	......
Bonds:									
Authorized—									
Number	......	1,050	......	......	......	......	......	......	......
Par value	......	$60,000	......	......	......	......	......	......	......
Issued—									
Number	......	350	......	......	......	......	......	......	......
Par value	......	$53,000	......	......	......	......	......	......	......
Interest paid	......	......	......	......	......	......	......	......	......
Assessments levied	......	......	$32,000	$54,750	$6,000	$1,678,996	......	$145,350	......

A comparison of the results shown in Tables 8 and 9 shows that the amount of outstanding stock and bonds of the companies which reported only development work in 1902 was greater than that of the companies reporting production, viz, $1,173,300,352 for the former as compared with $1,024,970,643 for the latter. The share of placers in the total outstanding capitalization of producing mines amounted to $68,005,794, or 6.6 per cent, while that of deep mines was $956,964,849.

The division of stock into common and preferred is not customary with gold and silver mining companies. In 1902 there were 77 companies having preferred stock, the par value of that issued being $23,804,445. This was only 1 per cent of the total outstanding capitalization of producing mines.

Assessment companies, once a prominent feature in gold and silver mining, are less conspicuous to-day. There were, in 1902, 250 assessment companies, of which 99 operated producing and 151 nonproducing mines. The amount of assessments levied since organization by the former was $21,200,119, and by the latter $31,657,563, a total of $52,857,682, representing an addition of 2 per cent to the total outstanding capital stock and funded indebtedness. The greater part of this amount, $42,966,822, was reported from Nevada, where assessments are still among the favorite means of raising funds for investment in gold and silver mining.

The issue of bonds was little favored, the total amount issued on producing and developing mines being only $10,120,741. The following statement shows the distribution of incorporated companies by the class of stock authorized and issued:

Incorporated companies, grouped by class of stock: 1902.

CLASS OF STOCK.	Number of incorporated companies.	AUTHORIZED.			ISSUED.		
		Total.	Common.	Preferred.	Total.	Common.	Preferred.
Operating producing mines: Total	1,079	$1,213,420,117	$1,194,317,427	$19,102,690	$1,017,011,793	$1,002,055,596	$14,956,197
Both common and preferred	31	62,229,600	43,126,910	19,102,690	52,649,632	37,693,435	14,956,197
Common only	1,048	1,151,190,517	1,151,190,517	....	964,362,161	964,362,161	....
Reporting development work without production: Total	1,695	1,908,351,126	1,891,552,126	16,799,000	1,171,138,461	1,162,290,213	8,848,248
Both common and preferred	46	60,159,000	43,360,000	16,799,000	37,534,728	28,686,480	8,848,248
Common only	1,649	1,848,192,126	1,848,192,126	....	1,133,603,733	1,133,603,733	....

The following table shows the par value of the authorized capital stock and bonds of all gold and silver mining companies engaged in deep or placer mining, producing and nonproducing, by states and territories, for 1902 and 1880:

TABLE 10.—*Authorized capitalization of incorporated companies, producing and nonproducing mines, by states and territories: 1902 and 1880.*

STATE OR TERRITORY.	1902		1880	
	Number of incorporated companies.	Capital stock and bonds authorized—par value.	Number of incorporated companies.	Capital stock and bonds authorized—par value.
United States	2,774	$3,134,950,483	458	$2,065,817,550
Alabama	3	3,004,000	....	....
Arizona	250	409,135,000	38	196,490,000
Arkansas	1	2,000,000	....	....
California	387	326,808,426	66	376,901,250
Colorado	822	851,641,287	126	325,902,300
Georgia	19	28,675,000	3	1,510,000
Idaho	233	201,776,440	13	54,145,000
Maine	....	....	11	6,400,000
Maryland	1	1,000,000	....	....
Montana	122	212,427,000	9	19,950,000
Nevada	105	110,449,080	78	759,645,000
New Hampshire	....	....	1	500,000
New Jersey	1	500,000	....	....
New Mexico	112	113,630,000	2	2,600,000
North Carolina	16	26,362,000	6	5,500,000
Oregon	148	232,405,800	2	5,000,000
South Carolina	2	750,000	....	....
South Dakota	103	201,920,000	21	118,800,000
Texas	1	150,000	....	....
Utah	255	182,044,000	42	156,200,000
Virginia	4	5,400,000	3	759,000
Washington	121	160,267,500	1	400,000
Wyoming	68	65,105,000	....	....
Placer mines not classified by states	....	....	36	35,115,000

There were in all 136 companies by which dividends were paid in 1902; of these 121 operated deep mines and 15 placer mines. The following statement shows the capitalization and dividends of all dividend paying companies and also the capitalization of the companies which paid no dividends in 1902.

The statement shows that the average par value per share of stock varied, ranging from a minimum of $1.47 for nondividend paying common stock to a maximum of $3.61 for dividend paying preferred. There was no material difference between the average par value of stock authorized and issued for dividend paying and nondividend paying companies, although the average for the former was somewhat higher than for the latter. Of the 136 companies which paid dividends in 1902, 4 paid them on preferred stock only. Their authorized capital stock was $3,925,000, of which $2,400,000 was common and $1,525,000 was preferred. The outstanding common stock amounted to $2,150,000 and the outstanding preferred to $1,457,632. The amount paid in dividends on preferred stock was $93,285. One company, with an authorized capital stock of $9,864,600, of which $5,918,800 was common and $3,945,800 was preferred, all being issued, paid in dividends $236,752 on common and $236,748 on preferred stock.

The average rate of dividends on common stock was 5.5 per cent and on preferred 6.1 per cent. One hundred and thirty-one other companies had only one class of stock upon which dividends were paid. There were 21 companies authorized to issue bonds of a total par value of $9,839,200; the bonds were issued of a par value of $7,958,850. The average value of bonds per share of stock authorized was $22.08 and per share issued, $26.88. The total amount of interest paid was $409,392, averaging 6 per cent. None of these 21 companies paid dividends on its stock.

Capitalization of dividend paying and nondividend paying companies with dividends and interest paid: 1902.

	AUTHORIZED.			ISSUED.			
	Number of shares or bonds.	Total par value.	Average per share or bond.	Number of shares or bonds.	Total par value.	Average per share or bond.	Dividends or interest paid.
Dividend paying companies:							
Total capitalization	119,629,807	$243,187,750	$2.03	94,717,950	$191,020,365	$2.01	$10,454,744
Common stock	118,065,349	237,716,950	2.01	93,220,860	185,616,933	1.99	10,124,711
Preferred stock	1,564,458	5,470,800	3.50	1,497,090	5,403,432	3.61	330,033
Nondividend paying companies:							
Total capitalization	654,678,002	980,071,567	1.50	516,623,891	833,950,278	1.61	409,392
Common stock	648,679,625	956,600,477	1.47	511,967,096	816,438,663	1.59	....
Preferred stock	5,552,799	13,631,890	2.45	4,360,648	9,552,765	2.19	....
Bonds	445,578	9,839,200	22.08	296,147	7,958,850	26.88	409,392

The following is a statement of dividends paid by incorporated companies in 1902 and 1884, compared with the production of the precious metals for the same years:

YEAR.	Number of mines.	Amount of dividends.	Gross value of the precious metals (commercial).
1902 [1]	136	$10,454,744	$85,223,732
1884 [2]	54	7,567,698	72,870,000

[1] Exclusive of Alaska.
[2] Report of the Director of the Mint on the Production of the Precious Metals in the United States, 1884, page 14.

A summary of dividend and nondividend paying companies is presented in Table 11. It must be borne in mind that the payment of dividends in a given year is not indicative of net profits earned during the same year, for dividends may be paid from the accumulated surplus of former years. Among the 136 companies which paid dividends were 15 whose expenditures, mostly for development work, during the year exceeded their receipts. The dividends declared by these companies aggregated $615,149, out of a total product valued at $1,059,617. It is obvious that these dividends had no relation to the earnings of the year. Likewise, the failure to declare a dividend does not necessarily show actual loss. Earnings may have been invested in development work, in new equipment of plants, in acquiring new property, etc. It is fair to assume, however, that generally the payment of dividends is a sign of successful operation. To facilitate comparisons, all incorporated companies are arranged under three heads: (1) Dividend paying—that is, companies that paid dividends during 1902; (2) nondividend paying companies owning productive mines; (3) developing and producing companies, meaning companies with which production was merely incidental to development work, expenditures being in excess of receipts.

TABLE 11.—SUMMARY FOR DIVIDEND PAYING AND NONDIVIDEND PAYING COMPANIES, BY CLASSES OF MINES: 1902.

	ALL MINES.				DEEP MINES.				PLACER MINES.			
			Nondividend paying.				Nondividend paying.				Nondividend paying.	
	Total.	Dividend paying.	Productive.	Developing and producing.	Total.	Dividend paying.	Productive.	Developing and producing.	Total.	Dividend paying.	Productive.	Developing and producing.
Number of operators	1,079	136	614	329	924	117	535	272	155	19	79	57
Salaries:												
General officers	$810,555	$241,747	$487,345	$81,463	$772,968	$225,312	$474,420	$73,236	$37,587	$16,435	$12,925	$8,227
Other salaried employees	$3,634,263	$1,340,319	$1,800,118	$493,826	$3,386,286	$1,301,095	$1,674,664	$410,527	$247,977	$39,224	$125,454	$83,299
Wages	$30,053,790	$11,156,704	$16,151,227	$2,745,859	$28,927,165	$10,856,454	$15,629,069	$2,441,642	$1,126,625	$300,250	$522,158	$304,217
Contract work	$521,921	$195,468	$177,724	$148,729	$511,436	$189,225	$177,587	$144,624	$10,485	$6,243	$137	$4,105
Work on share of product	$1,164,955	$277,991	$777,739	$109,225	$1,164,315	$277,991	$777,099	$109,225	$640	....	$640	....
Miscellaneous expenses	$4,419,537	$2,044,522	$2,013,436	$361,579	$4,223,025	$2,008,492	$1,889,576	$324,957	$196,512	$36,030	$123,860	$36,622
Cost of supplies and materials	$14,677,977	$5,470,101	$7,953,299	$1,254,577	$14,081,894	$5,305,252	$7,669,827	$1,106,815	$596,083	$164,849	$283,472	$147,762
Ore sold and treated, short tons	8,464,023	3,222,980	5,108,251	132,792	8,464,023	3,222,980	5,108,251	132,792	....	....	....	....
Value of bullion contents:												
Gold	$54,023,002	$26,531,623	$26,107,659	$1,383,720	$51,520,030	$25,531,958	$24,746,100	$1,241,972	$2,502,972	$999,665	$1,361,559	$141,748
Silver	$18,563,353	$11,317,764	$6,530,997	$714,592	$18,561,793	$11,317,210	$6,530,100	$714,483	$1,560	$554	$897	$109
Lead	$10,199,325	$6,958,295	$3,136,101	$104,929	$10,199,325	$6,958,295	$3,136,101	$104,929	....	....	....	....
Other metals	$1,300,649	$624,468	$574,098	$102,083	$1,300,185	$624,468	$573,640	$102,077	$464	....	$458	$6
Total gross value	$84,086,329	$45,432,150	$36,348,855	$2,305,324	$81,581,333	$44,431,931	$34,985,941	$2,163,461	$2,504,996	$1,000,219	$1,362,914	$141,863
Average per ton	....	....	....	....	$10	$14	$7	$16	....	....	....	....
Value of product at mine	$68,327,754	$35,307,932	$31,578,495	$1,441,327	$65,831,994	$34,311,515	$30,220,570	$1,299,909	$2,495,760	$996,417	$1,357,925	$141,418
Average per mine	$63,325	$259,617	$51,431	$4,381	$71,247	$293,261	$56,487	$4,779	$16,102	$52,443	$17,189	$2,481

The preceding table shows that the dividend paying companies contributed over one-half of the output. Taking deep mines alone and eliminating companies with which production was merely incidental to development work, it will be observed that the grade of ore mined by dividend paying companies was worth $14 per ton, whereas the ore mined by nondividend paying companies was worth only $7.

Employees and wages.—The average number of wage-earners employed in gold and silver mines was 47,905 men, of whom 33,821 were employed in deep mines, 2,321 in placer mines, and 11,763 in mines reporting only development work. Their total wages amounted to $47,658,176. In any analysis of these figures it must be borne in mind that the above number of wage-earners is an average, computed on the basis of 300 working days, and is *not identical with the actual number of* persons who earned the amount of wages reported. The average per wage-earner accordingly represents the cost of one man's labor to the employer, which is not identical with the average annual earnings. For the purpose of estimating the earning capacity of wage-earners, average daily rates should be consulted.

The following table shows the distribution of wage-earners according to daily rates of pay for the several classes of employees:

TABLE 12.—DISTRIBUTION OF WAGE-EARNERS ACCORDING TO DAILY RATES OF PAY, BY OCCUPATIONS: 1902.

RATE PER DAY (DOLLARS).	ALL CLASSES.		ENGINEERS.		FIREMEN.		MACHINISTS, BLACKSMITHS, CARPENTERS, AND OTHER MECHANICS.		MINERS.		MINERS' HELPERS.		TIMBERMEN AND TRACK LAYERS.		BOYS UNDER 16 YEARS.		ALL OTHER WAGE-EARNERS.	
	Average number.	Per cent of total.	Average number	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.
Total	47,905	100.0	2,129	100.0	553	100.0	3,405	100.0	28,068	100.0	3,864	100.0	574	100.0	33	100.0	9,279	100.0
Less than 0.50	16	(1)	......	......	......	......	......	......	......	......	......	......	......	......	5	15.2	11	0.1
0.50 to 0.74	72	0.2	......	......	......	......	......	......	11	(1)	25	0.7	......	......	7	21.2	29	0.3
0.75 to 0.99	397	0.8	7	0.3	4	0.7	13	0.4	172	0.6	112	2.9	......	......	5	15.2	84	0.9
1.00 to 1.24	544	1.1	30	1.4	19	3.4	19	0.6	242	0.9	78	2.0	......	......	3	9.0	153	1.7
1.25 to 1.49	351	0.7	15	0.7	1	0.2	36	1.1	183	0.6	28	0.7	......	......	5	15.2	83	0.9
1.50 to 1.74	506	1.1	9	0.4	5	0.9	16	0.5	249	0.9	53	1.4	4	0.7	3	9.0	167	1.8
1.75 to 1.99	718	1.5	3	0.2	5	0.9	13	0.4	250	0.9	103	2.7	......	......	......	......	344	3.7
2.00 to 2.24	1,536	3.2	8	0.4	19	3.4	80	2.3	439	1.6	180	4.7	2	0.3	5	15.2	803	8.7
2.25 to 2.49	928	1.9	2	0.1	9	1.6	23	0.7	337	1.2	210	5.4	2	0.3	......	......	345	3.7
2.50 to 2.74	6,641	13.9	51	2.4	77	13.9	161	4.7	3,633	12.9	916	23.7	66	11.5	......	......	1,737	18.7
2.75 to 2.99	3,603	7.5	28	1.3	28	5.1	81	2.4	2,829	10.1	142	3.7	26	4.5	......	......	469	5.1
3.00 to 3.24	15,994	33.4	460	21.6	169	30.6	682	20.0	10,101	36.0	1,188	30.7	191	33.3	......	......	3,203	34.5
3.25 to 3.49	1,922	4.0	94	4.4	5	0.9	136	4.0	981	3.5	259	6.7	29	5.1	......	......	418	4.5
3.50 to 3.74	10,043	21.0	478	22.5	158	28.6	791	23.2	6,921	24.7	554	14.3	210	36.6	......	......	931	10.0
3.75 to 3.99	468	1.0	45	2.1	3	0.6	73	2.1	299	1.1	5	0.1	9	1.6	......	......	34	0.4
4.00 to 4.24	3,544	7.4	762	35.8	46	8.3	998	29.3	1,358	4.8	11	0.3	32	5.6	......	......	337	3.6
4.25 and over	622	1.3	137	6.4	5	0.9	283	8.3	63	0.2	......	......	3	0.5	......	......	131	1.4

[1] Less than one-tenth of 1 per cent.

As shown by the above table, practically all of the wage-earners in gold and silver mines received $2 per day or over. When the figures for the several classes are combined it is found that 93.3 per cent of the total number received between $2 and $4.24. The statistics show a very large concentration of the wage-earners in three rate groups, as follows: 13.9 per cent of the total number in group $2.50 to $2.74, 33.4 per cent in group $3 to $3.24, and 21 per cent in group $3.50 to $3.74. Most of the employees included in these groups probably received the even rates $2.50, $3 or $3.50 per day.

More than half of the wage-earners were returned as miners. Their wages ranged between narrow limits, 87.2 per cent of the total number having been paid from $2.50 to $3.74 per day. In the rate group $3 to $3.24 are included 36 per cent of all the miners reported. There were also 3,864 men returned as miners' helpers, about one-seventh the number of miners. The rates of pay for these helpers were somewhat lower than those paid to the miners.

The rates paid to engineers, machinists, and other mechanics were *higher than those of the other wage-earners*; 92.8 per cent of the engineers and 86.9 per cent of the machinists and other mechanics received $3 per day or over. At $4 or more the respective proportions were 42.2 and 37.6 per cent. The rates for firemen were somewhat lower, a much greater proportion of them having been paid less than $3 per day. The range of wages for 79.1 per cent of the firemen was from $2.50 to $3.74 per day. There were 574 timbermen and track layers reported, all but 8 of whom received $2.50 per day or more. The daily rates for the great part of these employees were probably $3 or $3.50, as 33.3 per cent of them are included in the group $3 to $3.24, and 36.6 per cent in the group $3.50 to $3.74.

The boys under 16 years employed in gold and silver mines numbered only 33, and constituted less than one-tenth of 1 per cent of the total number of wage-earners. Five of these boys received less than 50 cents a day, and the rest of them were paid between 50 cents and $2.24.

The group of "all other wage-earners" includes 9,279 men who were not reported under the more specific heads. The rates of pay for these employees were somewhat lower than those for the wage-earners already considered, about one-fifth (21.8 per cent) having been paid less than $2.50 per day. The majority of them, however, received at least $2.50 and a large proportion received considerably more than that. The group showing the greatest number of employees is that from $3 to $3.24; in that one group are included 34.5 per cent of all the wage-earners in this class.

Table 13 shows the distribution of wage-earners according to daily rates of pay for those states which employed on the average more than one thousand wage-earners. In addition to the number included in each rate group, the percentages which these numbers form of the state total are given and also the cumulative percentages which show for each rate the proportion of the total number receiving that rate or more.

TABLE 13.—DISTRIBUTION OF WAGE-EARNERS ACCORDING TO DAILY RATES OF PAY, BY STATES AND TERRITORIES: 1902.

[Each cumulative percentage shows the proportion of the total number receiving a wage as great as, or greater than, the lowest wage of the given wage group.]

RATE PER DAY (DOLLARS).	UNITED STATES.			ARIZONA.			CALIFORNIA.			COLORADO.			IDAHO.		
	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.
Total	47,905	100.0	...	3,685	100.0	...	9,436	100.0	...	13,503	100.0	...	4,234	100.0	...
Less than 0.50	16	[1]	100.0	...	...	...	1	[1]	100.0	...	...	...	1	[1]	100.0
0.50 to 0.74	72	0.2	99.9	...	...	...	4	[1]	99.9	1	[1]	100.0	...	...	99.9
0.75 to 0.99	397	0.8	99.8	1	[1]	100.0	1	[1]	99.9	1	[1]	99.9	3	0.1	99.9
1.00 to 1.24	544	1.1	99.0	7	0.2	99.9	16	0.2	99.9	8	0.1	99.9	22	0.5	99.9
1.25 to 1.49	351	0.7	97.9	27	0.7	99.8	30	0.3	99.8	6	[1]	99.9	13	0.3	99.4
1.50 to 1.74	506	1.1	97.2	135	3.7	99.1	105	1.1	99.5	15	0.1	99.9	8	0.2	99.1
1.75 to 1.99	718	1.5	96.1	148	4.0	95.4	230	2.4	98.4	160	1.2	99.8	10	0.2	98.9
2.00 to 2.24	1,536	3.2	94.6	241	6.5	91.4	409	4.3	96.0	327	2.4	98.6	36	0.9	98.7
2.25 to 2.49	928	1.9	91.4	35	1.0	84.9	472	5.0	91.7	77	0.6	96.2	14	0.3	97.8
2.50 to 2.74	6,641	13.9	89.5	188	5.1	83.9	3,077	32.6	86.7	1,360	10.1	95.6	64	1.5	97.5
2.75 to 2.99	3,603	7.5	75.6	115	3.1	78.8	1,290	13.7	54.1	935	6.9	85.5	86	2.0	96.0
3.00 to 3.24	15,994	33.4	68.1	874	23.7	75.7	2,835	30.1	40.4	6,529	48.3	78.6	1,184	28.0	94.0
3.25 to 3.49	1,922	4.0	34.7	173	4.7	52.0	193	2.1	10.3	606	4.5	30.3	625	14.8	66.0
3.50 to 3.74	10,043	21.0	30.7	1,229	33.4	47.3	488	5.2	8.2	1,541	11.4	25.8	1,831	43.2	51.2
3.75 to 3.99	468	1.0	9.7	19	0.5	13.9	40	0.4	3.0	264	2.0	14.4	12	0.3	8.0
4.00 to 4.24	3,544	7.4	8.7	418	11.4	13.4	209	2.2	2.6	1,488	11.0	12.4	277	6.6	7.7
4.25 and over	622	1.3	1.3	75	2.0	2.0	36	0.4	0.4	185	1.4	1.4	48	1.1	1.1

RATE PER DAY (DOLLARS).	MONTANA.			NEVADA.			SOUTH DAKOTA.			UTAH.			ALL OTHER STATES AND TERRITORIES.		
	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.
Total	2,759	100.0	...	1,649	100.0	...	3,436	100.0	...	4,285	100.0	...	4,918	100.0	...
Less than 0.50	...	...	...	2	0.1	100.0	...	...	...	1	[1]	100.0	11	0.2	100.0
0.50 to 0.74	...	...	...	...	...	99.9	...	...	...	...	...	99.9	67	1.4	99.8
0.75 to 0.99	...	...	...	1	0.1	99.9	...	...	...	...	...	99.9	390	7.9	98.4
1.00 to 1.24	1	[1]	100.0	1	0.1	99.8	...	...	...	10	0.2	99.9	479	9.7	90.5
1.25 to 1.49	...	...	99.9	...	...	99.7	...	...	...	6	0.1	99.8	269	5.5	80.8
1.50 to 1.74	...	...	99.9	65	3.9	99.7	10	0.3	100.0	1	[1]	99.7	167	3.4	75.3
1.75 to 1.99	1	[1]	99.9	16	1.0	95.8	...	...	99.7	6	0.1	99.7	147	3.0	71.9
2.00 to 2.24	3	0.1	99.9	14	0.8	94.8	18	0.5	99.7	153	3.6	99.6	335	6.8	68.9
2.25 to 2.49	...	...	99.9	2	0.1	94.0	1	[1]	99.2	238	5.6	96.0	89	1.8	62.1
2.50 to 2.74	20	0.7	99.9	46	2.8	93.9	242	7.1	99.2	1,121	26.2	90.4	523	10.6	60.3
2.75 to 2.99	...	...	99.2	76	4.6	91.1	4	0.1	92.1	936	21.8	64.2	161	3.3	49.7
3.00 to 3.24	436	15.8	99.2	641	38.9	86.5	1,064	31.0	92.0	1,297	30.3	42.4	1,134	23.1	46.4
3.25 to 3.49	29	1.1	83.4	57	3.5	47.6	8	0.2	61.9	140	3.3	12.1	91	1.8	23.3
3.50 to 3.74	1,816	65.8	82.3	217	13.2	44.1	1,852	53.9	60.8	274	6.4	8.8	795	16.2	21.5
3.75 to 3.99	46	1.7	16.5	8	0.5	30.9	6	0.2	6.9	36	0.8	2.4	37	0.8	5.3
4.00 to 4.24	337	12.2	14.8	418	25.3	30.4	145	4.2	6.7	59	1.4	1.6	193	3.9	4.5
4.25 and over	70	2.6	2.6	85	5.1	5.1	86	2.5	2.5	7	0.2	0.2	30	0.6	0.6

[1] Less than one-tenth of 1 per cent.

Of the states for which statistics are presented separately in the above table, rates were highest in Montana. Practically all of the wage-earners in that state received at least $3 per day, and 82.3 per cent of them were paid $3.50 or over. In the single group $3.50 to $3.74 are included 65.8 per cent of all the wage-earners and a large proportion of these probably received exactly $3.50 per day.

In South Dakota, Idaho, and Nevada the rates paid were somewhat less than in Montana, but between the three states there was, on the whole, comparatively little difference. At first glance it would seem that of the three states rates were highest in Nevada, for that state shows an exceptionally large proportion of wage-earners at $4 and over. It will be noticed, however, that the proportions at $3 or more and at $3.50 or more are greater in South Dakota and Idaho than in Nevada, while the proportions receiving less than $3 are smaller. Of the wage-earners in South Dakota, 53.9 per cent are included in the single group $3.50 to $3.74, and 31 per cent in the group $3 to $3.24. In Idaho 86 per cent are included in three consecutive groups, constituting the range from \$3 to \$3.74 per day. There was a greater divergence in the wages paid in Nevada, the group including the greatest number of employees being that from \$3 to \$3.24, and the one including the next largest number being that from \$4 to \$4.24.

Following the states above mentioned in the order of the rates paid come Colorado and Arizona. In these two states, also, there was on the whole comparatively little difference in wages. In Colorado the range of wages for 94.2 per cent of the wage-earners was from \$2.50 to \$4.24 per day, 48.3 per cent being included in the single group \$3 to \$3.24. In Arizona the wage-earners were distributed in smaller groups over a wider range. Practically all of them (97.1 per cent) received between \$1.50 and \$4.24 per day. The greatest concentration in Arizona is at \$3 to \$3.50 per day, 23.7 per cent being included in group \$3 to \$3.24 and 33.4 per cent in group \$3.50 to \$3.74.

Of the states which employed, on the average, more than one thousand wage-earners, California and Utah show the lowest rates. In each of these states the greater part of the wage-earners received between \$2.50 and \$3.24 per day, the proportion included between those limits being 76.4 per cent for California and 78.3 per cent for Utah.

It will be noticed that the statistics grouped under "all other states and territories" include practically all the returns for wage-earners receiving less than \$1.50 per day. This is due to the inclusion of several Southern states, in which rates of wages were low. They reported a comparatively small number of wage-earners. The employees at the higher rates included under "all other states and territories" were principally in Oregon, New Mexico, and Washington, where rates were approximately the same as in the Western states, for which a separate showing is made in Table 13.

In addition to regular wage-earners employed by the day or by the task, there is a special class of labor variously designated as "leasers," "block lessees," "tributers," "chloriders," etc. Technically, they "lease" from the operator a block in the mine and "pay" a stipulated royalty, which varies with the richness of the ore; in reality all the ore hoisted is usually delivered to the operator and marketed by him, or else it is shipped in his name to the sampler or smelter; the operator retains his royalty, or authorizes the ore buyer to withhold the same, and pays to the "lessees" their share of the proceeds. In all cases these workers furnish their own mine supplies. While resembling in form an ordinary mining lease, this is in substance a contract of employment on a share of the product.

The average number of miners employed on a share of the product in 1902 was 1,280, and the total compensation received by them amounted to \$1,452,692, which included the cost of supplies furnished by them. This system is in vogue chiefly in Colorado, which reported 158 mines worked on shares, with 823 "leasers." California had 27 such mines; Montana, 18; Nevada, 7; Idaho, 3; New Mexico, 3; Arizona, 3; Oregon, 2; and Georgia and North Carolina, 1 each.

A summary of mines employing this class of labor is presented in the table next following. Deep mines are divided into two groups—those worked on shares only and those employing both share and wage workers. There were only 2 placer mines reported as having both classes of labor; these 2 mines are therefore omitted from the table. The mines worked exclusively on shares were small. The larger mines where this system was practiced also employed regular wage-earners.

TABLE 14.—*Summary for mines worked on shares: 1902.*

	DEEP.			PLACER.
	Total.	Without wage labor.	With wage labor.	Without wage labor.
Number of mines	203	162	41	18
Number of owners working	11	11	....	....
Salaries	\$219,208	\$19,224	\$199,984	....
Wages	\$1,093,176	....	\$1,093,176	....
Contract work	\$35,555	\$9,120	\$26,435	\$187
Share workers:				
Number	1,122	447	675	130
Amount paid	\$1,375,843	\$557,602	\$818,241	\$64,255
Miscellaneous expenses	\$236,959	\$39,266	\$197,693	\$2,335
Cost of supplies and materials	\$487,298	\$18,055	\$469,243	\$4,880
Ore sold and treated, short tons	331,526	57,158	274,368	....
Value of bullion contents:				
Gold	\$3,513,849	\$709,241	\$2,804,608	\$89,004
Silver	\$1,236,292	\$292,037	\$944,255	....
Other metals	\$223,479	\$64,815	\$158,664	\$223
Total gross value	\$4,973,620	\$1,066,093	\$3,907,527	\$89,227
Average per ton	\$15	\$18	\$14	....
Value of product at mine	\$3,585,254	\$728,885	\$2,856,369	\$88,105
Average per mine	\$17,661	\$4,499	\$20,258	\$4,895

There are a number of gold and silver mines in which manual labor is performed by the owners, either with or without the assistance of hired help. The total number of owners so employed in producing mines was reported as 1,495 and the number so engaged in mines under development was 609. There were in all 599 producing mines and 281 under development which employed no hired labor at all. It must be borne in mind, however, that the census agents were instructed to omit from their canvass mines where less than two wage-earners were employed. The above numbers, therefore, include only such mines as were reached by correspondence and those which were supposed from preliminary information to come within the scope of the canvass, but were found upon personal inquiry by special agents to employ no hired labor. The total number of men engaged in working their own mines without hired labor, or with but casual help, must be considerably larger than the number reported.

A summary for mines operated without hired labor, as far as reported, is presented in the following table:

TABLE 15.—*Summary for mines operated without hired labor: 1902.*

	Total.	Placer.	Deep.
Number of mines	599	396	203
Number of owners working	1,165	774	391
Contract work	$1,685	....	$1,685
Miscellaneous expenses, total	$31,094	$18,557	$12,537
Rent and royalties	$26,057	$15,100	$10,957
Mines and mineral lands	$18,966	$8,312	$10,654
Water	$2,536	$2,317	$219
Other	$4,555	$4,471	$84
Other miscellaneous expenses	$5,037	$3,457	$1,580
Cost of supplies and materials	$41,745	$21,248	$20,497
Ore sold or treated, short tons	9,332	....	9,332
Average per deep mine	46	....	46
Total gross value	$528,496	$293,176	$235,320
Average per ton	$25	....	$25
Treatment charges and freight	$45,928	$1,407	$44,521
Value of product at mine	$482,568	$291,769	$190,799
Average per mine	$806	$737	$940

The average output per mine, as shown in the preceding table, was less than one thousand dollars; the output of ore in an average deep mine operated without hired labor was 46 tons, and there were about two owners working in an average mine. It is evident that the work did not occupy the entire time of the owners. This must be borne in mind if it is desired to make comparisons with other mines. Ore bringing $25 per ton is considered a high-grade product.

The mines at which owners were reported to be doing manual labor include cooperative mines, the number of which was 25. Of this number there were 11 mines each of which reported less than five men employed.

The term "cooperative" as applied to such mines is somewhat vague. A "cooperative association" consisting of from two to four men, often working by turns and devoting to the work only such time as can be spared from other occupations, is not easily distinguished from an ordinary partnership. If 5 members be considered the minimum for a cooperative association, there were 14 such associations, with 171 working members; in addition to these, 1 man was hired for wages. Of these associations, 1 with 12 working members was incorporated, with a capital stock of $60,000, and upon this capital a dividend of 6 per cent was paid. This mine is also included among those owned by incorporated companies. The greatest number of men reported by a single association was 23. Twelve associations, with a combined membership of 136 men, were engaged in placer mining, and 2 with 35 men were operating deep mines. The membership of these associations included 101 Chinese and 70 persons of all other nationalities. The Chinese were working exclusively in placer mines. There were in all 8 associations composed exclusively of Chinese, with a total membership of 95 men; the greatest number reported by any Chinese association was 16. There were 5 associations, with a total membership of 68 men, composed of other nationalities and 1 with a mixed membership.

The total output of all cooperative associations was valued at the mine at $92,313, averaging $6,594 per mine. The mines are grouped by the value of production, as follows: One with an output of less than $500; 3 with an output exceeding $500 but less than $1,000; 7 with an output exceeding $1,000 but less than $10,000; and 2 with an output exceeding $10,000 but less than $50,000.

Contract work.—An amount of contract work in and about the mines was done by individuals, firms, and companies making a specialty of certain classes of work. The total amount paid for contract work was $2,168,861, of which $1,542,771 was paid at mines where development work alone was prosecuted, and $626,090 at producing mines. The latter amount was nearly all expended in development work, such as tunneling, shaft sinking, drifting, running levels and winzes, etc. Mining proper (stoping) was only in two cases reported as being done by contract along with development work, the total expenditure for contract work in these two cases amounting to $46,888. Pumping was reported in two cases only, the total amount being insignificant. In a few cases cutting and hauling of wood and timber, roadmaking, and building and cleaning of ditches were reported, the total expense amounting to $15,414.

The number of men employed on contract work could not always be stated accurately by mine operators, for the reason that they had no direct control over the men employed by the contractors. Very frequently the number of men to be furnished by the contractor was stipulated in the contract. Still the time consumed by them in doing the work was in most cases not stated; therefore the number of men could not be reduced to an annual average basis of 300 working days, and duplications could not be avoided. The same men working in a mining camp on a number of mines successively were reported by several operators. The total number reported for producing mines was 980 men, whereas in mines reporting development work only, the number of men employed by contractors aggregated as many as 5,649. The number of men reported in each class of mines shows an extreme disproportion to the amounts paid for contract work. It is apparent that in some cases the number of men must have been underestimated, whereas in others there were probably many duplications.

The several classes of labor presented under the head of "employees and wages" and "contract work" comprise an average of 47,905 regular wage-earners, 1,280 workers for a share of the product, 2,104 owners doing manual labor, and 6,629 men employed by contractors. In addition to these, 5,135 prospectors reported 5,519 mining claims, upon which, in compliance with the mining laws, the sum of $551,900 ought to have been expended in assessment work. Considering that many mines were operated only at certain seasons and that during a portion of the year the miners had to employ their time in other industries, it may be conservatively estimated that from 50,000 to 60,000 men found employment in gold and silver mining.

Time in operation.—Tables 16, 17, 18, 19, and 20 present a classification of producing mines by the number of days in operation, number of shifts employed per day, and number of hours per shift, and a like classification of all mills whenever separately reported.

For a number of the mills combined with mines only one report was made for both mill and mine, in which case the report was included with the number of mills. There were, as stated on a preceding page, 599 mines in which no hired labor was employed, not including 162 mines where all miners were working on a share of the product, and 2,393 mines and mills with regular wage-earners. Many of the two former classes failed to report the number of days and hours in operation. The number of mines reporting the days in operation was 2,525, and the number reporting the hours in operation was 2,494. The total number of mines shown in Tables 18 and 19 includes a duplication of 34 mines which reported different hours for various classes of employees. All other mines reported the same hours for all employees.

TABLE 16.—*Number of mines, classified according to number of days in operation, by states and territories: 1902.*

STATE OR TERRITORY.	Total number reporting.	DAYS. 30 and less.	31 to 60.	61 to 90.	91 to 120.	121 to 150.	151 to 180.	181 to 210.	211 to 240.	241 to 270.	271 to 300.	301 to 330.	331 to 365.
United States.	2,525	96	211	218	253	201	197	169	131	127	294	176	452
Alabama	3	1	....	....	1	....	....	....	....	....	1	....	....
Arizona	67	1	9	4	2	4	8	3	6	8	2	3	22
Arkansas	1	....	....	....	....	....	....	....	....	....	1	....	....
California	812	36	69	73	93	62	64	68	29	50	109	59	100
Colorado	648	19	50	49	45	53	35	34	38	32	88	60	145
Georgia	43	4	6	4	3	5	3	7	1	....	8	1	1
Idaho	206	9	21	24	35	21	13	13	10	4	20	2	31
Maryland	1	....	....	....	1	....	....	....	....	....	....	....	....
Montana	175	6	7	11	19	13	19	9	11	6	14	15	45
Nevada	74	1	4	4	3	4	6	3	5	5	13	5	21
New Mexico	82	5	12	10	8	6	4	7	5	7	7	6	5
North Carolina	13	....	....	....	2	....	....	1	2	....	8	....	....
Oregon	240	8	27	32	32	21	32	19	16	10	11	13	19
South Carolina	3	1	....	....	....	....	....	....	....	....	2	....	....
South Dakota	38	2	1	1	3	5	2	1	1	1	3	3	15
Tennessee	2	....	....	....	....	....	1	....	....	....	1	....	....
Texas	1	....	....	....	....	....	....	....	....	....	....	....	1
Utah	81	....	2	4	2	4	6	3	5	5	5	7	38
Virginia	4	1	....	....	....	1	....	....	....	1	....	1	....
Washington	27	2	2	2	4	2	3	1	2	2	1	1	5
Wyoming	4	....	1	....	....	....	1	....	....	1	....	....	1

TABLE 17.—*Number of mills, classified according to number of days in operation, by states and territories: 1902.*

STATE OR TERRITORY.	Total number reporting.	DAYS. 30 and less.	31 to 60.	61 to 90.	91 to 120.	121 to 150.	151 to 180.	181 to 210.	211 to 240.	241 to 270.	271 to 300.	301 to 330.	331 to 365.
United States.	482	81	76	40	36	31	23	17	13	24	34	17	90
Alabama	1	1	....	....	....	....	....	....	....	....	....	....	....
Arizona	29	6	6	3	....	1	....	1	1	....	1	3	7
California	235	42	38	21	19	19	13	6	10	10	11	2	44
Colorado	71	4	8	6	4	4	2	3	1	4	6	6	23
Georgia	10	2	2	1	2	....	1	....	....	....	1	....	1
Idaho	45	12	9	4	2	8	1	1	....	....	6	1	6
Montana	9	2	....	....	1	2	....	1	....	1	....	2	....
Nevada	24	3	4	....	1	....	3	....	....	2	4	2	5
New Mexico	18	5	4	4	1	....	1	2	....	1	....	....	....
North Carolina	1	....	....	....	1	....	....	....	....	....	....	....	....
Oregon	6	1	1	....	3	1	....	....	....	....	....	....	....
South Carolina	1	....	....	....	....	....	....	....	....	....	1	....	....
South Dakota	10	....	....	1	1	....	....	1	....	4	....	1	2
Utah	17	2	1	....	1	1	1	2	1	2	4	....	2
Virginia	1	....	1	....	....	....	....	....	....	....	....	....	....
Washington	2	....	1	....	....	....	1	....	....	....	....	....	....
Wyoming	2	1	1	....	....	....	....	....	....	....	....	....	....

TABLE 18.—*Number of mines and mills in the United States, classified according to number of working shifts per day, and number of hours per shift: 1902.*

HOURS IN OPERATION.	MINES. Total reporting.	Running 1 shift.	Running 2 shifts.	Running 3 shifts.	MILLS. Total reporting.	Running 1 shift.	Running 2 shifts.	Running 3 shifts.
United States.	2,528	1,767	621	140	479	166	276	37
Less than 8 hours	13	13	....	....	....	....	....	....
8 hours	929	589	200	140	60	10	13	37
9 hours	362	270	92	....	15	11	4	....
10 hours	1,099	872	227	....	69	58	11	....
11 hours	9	3	6	....	4	2	2	....
12 hours	116	20	96	....	331	85	246	....

TABLE 19.—NUMBER OF MINES, CLASSIFIED ACCORDING TO NUMBER OF WORKING SHIFTS PER DAY, AND NUMBER OF HOURS PER SHIFT, BY STATES AND TERRITORIES: 1902.

STATE OR TERRITORY.	Total reporting.	RUNNING 1 SHIFT. Total.	Less than 8 hours	8 hours	9 hours	10 hours	11 hours	12 hours	RUNNING 2 SHIFTS. Total.	Less than 8 hours	8 hours	9 hours	10 hours	11 hours	12 hours	RUNNING 3 SHIFTS. Total.	Less than 8 hours	8 hours	9 hours	10 hours	11 hours	12 hours
United States.	2,528	1,767	13	589	270	872	3	20	612	....	200	92	227	6	96	140	....	140	....	....	....	....
Alabama	3	2	....	....	....	2	....	....	1	....	....	....	1	....	....	....	....	....	....	....	....	....
Arizona	70	43	....	....	13	28	....	2	20	....	2	3	13	....	2	7	....	7	....	....	....	....
Arkansas	1	1	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
California	812	571	3	62	131	365	1	9	191	....	8	24	118	....	41	50	....	50	....	....	....	....
Colorado	659	461	4	360	65	32	....	....	174	....	114	44	12	....	4	24	....	24	....	....	....	....
Georgia	37	31	....	....	....	30	1	....	6	....	....	....	....	....	6	....	....	....	....	....	....	....
Idaho	203	140	2	31	10	91	1	5	55	....	4	6	29	1	15	8	....	8	....	....	....	....
Maryland	1	1	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Montana	174	111	1	77	2	31	....	....	43	....	30	....	7	....	6	20	....	20	....	....	....	....
Nevada	74	46	....	15	5	26	....	....	23	....	6	4	7	....	6	5	....	5	....	....	....	....
New Mexico	82	68	....	8	24	36	....	....	13	....	3	2	7	....	1	1	....	1	....	....	....	....
North Carolina	12	9	....	....	....	8	....	1	....	....	....	....	....	....	....	3	....	3	....	....	....	....
Oregon	246	203	2	10	12	176	....	3	37	....	1	4	13	5	14	6	....	6	....	....	....	....
South Carolina	3	1	....	....	....	1	....	....	2	....	....	....	2	....	....	....	....	....	....	....	....	....
South Dakota	39	26	....	....	1	25	....	....	11	....	....	1	9	....	1	2	....	2	....	....	....	....
Tennessee	2	2	....	....	....	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Texas	1	1	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Utah	82	34	1	24	4	5	....	....	34	....	31	2	1	....	....	14	....	14	....	....	....	....
Virginia	4	3	....	....	....	3	....	....	1	....	....	....	1	....	....	....	....	....	....	....	....	....
Washington	19	9	....	2	....	7	....	....	10	....	1	2	7	....	....	....	....	....	....	....	....	....
Wyoming	4	4	....	....	3	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

TABLE 20.—NUMBER OF MILLS, CLASSIFIED ACCORDING TO NUMBER OF WORKING SHIFTS PER DAY, AND NUMBER OF HOURS PER SHIFT, BY STATES AND TERRITORIES: 1902.

STATE OR TERRITORY.	Total reporting.	RUNNING 1 SHIFT.							RUNNING 2 SHIFTS.							RUNNING 3 SHIFTS.						
		Total.	Less than 8 hours	8 hours	9 hours	10 hours	11 hours	12 hours	Total.	Less than 8 hours	8 hours	9 hours	10 hours	11 hours	12 hours	Total.	Less than 8 hours	8 hours	9 hours	10 hours	11 hours	12 hours
United States	479	166	......	10	11	58	2	85	276	......	13	4	11	2	246	37	......	37	......	......	......	......
Alabama	1	1	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Arizona	28	17	......	......	1	5	......	11	10	......	......	......	......	......	10	1	......	1	......	......	......	......
California	235	91	......	1	5	32	1	52	132	......	2	2	6	2	120	12	......	12	......	......	......	......
Colorado	72	11	......	4	1	2	......	4	52	......	2	......	1	......	49	9	......	9	......	......	......	......
Georgia	9	3	......	......	......	2	......	1	6	......	......	1	......	......	5	......	......	......	......	......	......	......
Idaho	44	15	......	1	2	8	......	4	29	......	......	......	1	......	28	......	......	......	......	......	......	......
Montana	9	1	......	......	......	......	......	1	1	......	1	......	......	......	......	7	......	7	......	......	......	......
Nevada	24	5	......	......	......	2	......	3	17	......	1	1	1	......	14	2	......	2	......	......	......	......
New Mexico	18	10	......	......	......	3	1	6	8	......	1	......	......	......	7	......	......	......	......	......	......	......
North Carolina	1	1	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Oregon	6	3	......	......	......	......	......	3	3	......	......	......	......	......	3	......	......	......	......	......	......	......
South Carolina	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	1	......	......	......	......
South Dakota	10	......	......	......	......	......	......	......	10	......	......	......	2	......	8	......	......	......	......	......	......	......
Utah	16	5	......	4	......	1	......	......	6	......	6	......	......	......	......	5	......	5	......	......	......	......
Virginia	1	1	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Washington	2	......	......	......	......	......	......	......	2	......	......	......	......	......	2	......	......	......	......	......	......	......
Wyoming	2	2	......	......	2	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

Supplies and materials and miscellaneous expenses.—The general term "materials" has scarcely any application to mining. The "material" operated upon in a mine is the rock underground or the gold bearing gravel. The inquiry calling for "total cost of supplies and materials of all kinds used during the year" at the mine contained the following explanatory note:

"The cost of the following materials should be reported under this inquiry: Lumber and timber used for repairs, mine supports, track ties, cars, and for all other purposes; iron and steel for blacksmithing; rails, frogs, sleepers, etc., for tracks and repairs; parts of machinery and tools used for renewals and repairs; explosives, water for boilers and for other purposes; fuel, illuminating and lubricating oils, machinery supplies, etc."

All the items here enumerated come strictly under the definition of "supplies." The "material" treated at the mills is the ore which comes from the mine. It is not customary in mining bookkeeping to charge the mill with the value of the ore brought from the mine. In the schedule relating to "reduction works, other than smelters," there were two separate inquiries, one relating to "materials," another to "supplies." The former called for a statement of the "character of materials used, whether ore, tailings, or other materials," and was confined to "materials bought in 1902." The amount reported in answer to this inquiry is not included in the cost of "supplies and materials" but is given elsewhere as a separate item.

The explanatory note to the inquiry relating to mill "supplies" enumerated: "Shoes, dies, screens, plates, and other parts of machinery and tools used for renewals and repairs; quicksilver, cyanide of potassium, lumber, iron, steel, oil, fuel, water, etc."

The total cost of "supplies and materials," as herein defined, was reported as $21,774,845, distributed as follows: Producing mines, deep, $15,908,782; placer, $790,986; developing mines, $5,075,077.

The item, "miscellaneous expenses," includes rent and royalties of all descriptions, "taxes, insurance, interest, advertising, office supplies, law expenses, injuries and damages, telegraph and telephone service, gas, and all other sundries not reported elsewhere."

The total amount of miscellaneous expenses of producing mines was $5,357,529, of which $1,419,155 was reported as rents and royalties of all descriptions for mines, and $3,938,374 for all other mine expenses and miscellaneous mill expenses; the latter item includes the sum of $4,244 paid by custom mills as royalties for the privilege of reworking old tailings.

The miscellaneous expenses of developing mines aggregated $1,017,356, of which rents and royalties of all descriptions amounted to only $71,131. That the amount of rents and royalties paid by this class of mines was so insignificant is in harmony with the character of the mines, royalties and rents being as a rule proportionate to the returns of the mine. Where the mine is not producing, the labor and expense incurred by the operator in developing the mine are a part consideration for the privilege of working the same.

Of the items making up the total royalties ($71,131), the principal expense ($41,916) was for the use of water, and the next largest sum ($16,153) was expended for electric power; other power (air, steam, etc.), cost $2,406; the rents of mines and mineral lands amounted to $4,528; expenditures on plant and improvements were $3,572; for tunnel privileges, $843; and rent of office and miscellaneous rents, $1,713.

The following is a statement of rents and royalties paid by producing mines:

Rents and royalties paid by producing mines: 1902.

	All mines.	Deep.	Placer.
Total	$1,419,155	$1,273,388	$145,767
Mines and mineral lands	696,372	649,565	46,807
Plant and improvements	84,721	80,544	4,177
Tunnel privileges	64,282	64,257	25
Water rent	287,010	243,346	43,664
Electric power	215,802	165,916	49,886
Air and steam power	2,111	2,111	....
Miscellaneous rents	68,857	67,649	1,208

The greater part of the royalties paid for the use of the mines and mineral lands, $500,550, was reported from Colorado; the amount reported by all other states was only $195,822. Royalties for tunnel privileges were reported as follows: Colorado, $43,954; Nevada, $12,482; Utah, $7,266; all other states, $580. The most of the payments for water rents, $210,641, was reported from California; the next largest sum, $40,707, was reported from Colorado, while all other states aggregated $35,662. The amount expended for rent of electric power was $215,802, of which $128,077 was reported from California and $87,725 from Colorado. The rent of other power was exceptional.

The royalties do not include those charged to so-called "block lessees," "tributers," etc., who made no reports to the census. Where the mine was worked by regular wage-earners as well as by tributers the amount charged against the latter as royalties could not be segregated. But where this was the only class of labor employed in mining the amount charged as royalties can be ascertained by deducting the amount paid to the lessees from the total value realized for the ore at the mine.

Mineral lands.—The primary distinction between mining and manufacturing is that in the latter only capital and labor are factors, while in the former industry there are three factors of production, viz, land, capital, and labor. The present census of mines and quarries is the first in which the scope of the inquiry has in some branches been extended to the ownership of mineral lands. Though the special schedule providing for gold, silver, lead, and copper mines confined itself to mineral lands, it is probable that in some cases the reports included lands of all descriptions, such as timbering lands, building lots, etc.

The acreage of mineral lands was reported for 5,845 mines, viz: Producing, deep, 1,913; producing, placer, 846; mines in the development stage, 3,086. No report of acreage was made for 178 producing, and for 166 developing, mines; these constituted 5.5 per cent of the total. The area reported by producing mines was 406,009 acres, of which 219,349 acres belonged to deep mines and 186,660 acres to placers; 653,001 acres were reported by mines under development. This shows that the area held for development exceeds by more than one-half the acreage of producing mines.

The leasing of mineral lands had only a subordinate part in gold and silver mining. The total area rented was 58,807 acres, 33,259 acres by operators of producing mines and 25,548 acres for development. The total royalties paid for the use of mineral lands amounted to $696,372, of which $46,807 was paid on placers and $649,565 for deep mines. In Table 21 all mines reporting acreage are arranged by the area owned and leased, by the character of mine, and by states and territories. The number of mines contains a duplication of 68 mines which were located on land partly owned and partly leased.

TABLE 21.—CLASSIFICATION OF MINES ACCORDING TO ACREAGE, BY STATES AND TERRITORIES: 1902.

	UNITED STATES.			ALABAMA.		ARIZONA.		ARKANSAS.		CALIFORNIA.		COLORADO.		GEORGIA.	
	Number of mines reporting.	Acreage. Total.	Acreage. Per cent.	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.
Producing mines:															
Deep—															
Land owned—															
Total	1,561	205,384	100.0	3	1,800	67	10,765	1	700	401	48,353	534	40,361	7	1,160
20 acres or less	495	7,263	3.5	....	....	6	105	....	....	139	2,571	232	2,489	3	60
21 to 99 acres	568	29,285	14.3	....	....	25	1,452	....	....	135	7,491	211	9,391	1	40
100 to 999 acres	469	113,732	55.4	2	400	36	9,208	1	700	122	26,539	85	19,861	3	1,060
1,000 acres and over	29	55,104	26.8	1	1,400	....	....	....	....	5	11,752	6	8,620	....	....
Land leased—															
Total	404	13,965	100.0	1	470	3	300	....	....	35	1,572	249	5,778	4	215
20 acres or less	264	3,235	23.2	....	....	....	....	....	....	21	252	180	1,719	2	60
21 to 99 acres	111	5,071	36.3	....	....	1	40	....	....	8	420	62	2,368	2	155
100 to 999 acres	29	5,659	40.5	1	470	2	260	....	....	6	900	7	1,691	....	....
Placer—															
Land owned—															
Total	787	167,366	100.0	1	80	2	740	....	....	467	83,834	17	9,838	3	1,250
20 acres or less	196	3,494	2.1	....	....	....	....	....	....	139	2,483	3	60	1	20
21 to 99 acres	273	14,549	8.7	1	80	....	....	....	....	165	8,717	1	40	....	....
100 to 999 acres	286	81,338	48.6	....	....	2	740	....	....	147	41,042	9	3,265	2	1,230
1,000 acres and over	32	67,985	40.6	....	....	....	....	....	....	16	31,592	4	6,473	....	....
Land leased—															
Total	75	19,294	100.0	1	80	....	....	....	....	39	10,713	3	740	1	708
20 acres or less	14	241	1.2	....	....	....	....	....	....	9	141	....	....	....	....
21 to 99 acres	27	1,379	7.2	1	80	....	....	....	....	13	558	1	40	....	....
100 to 999 acres	29	8,397	43.5	....	....	....	....	....	....	13	3,737	2	700	1	708
1,000 acres and over	5	9,277	48.1	....	....	....	....	....	....	4	6,277	....	....	....	....
Development work without production:															
Owned and leased—															
Total	3,086	653,001	100.0	3	3,760	372	70,346	1	80	353	174,138	915	83,461	2	340
20 acres or less	681	9,443	1.4	....	....	29	516	....	....	97	1,740	401	4,372	1	20
21 to 99 acres	1,076	59,858	9.2	....	....	99	6,263	1	80	102	5,891	350	16,382	....	....
100 to 999 acres	1,277	294,221	45.1	2	960	240	58,698	....	....	142	39,517	157	30,877	1	320
1,000 acres and over	47	101,151	15.5	1	2,800	4	4,839	....	....	11	26,990	6	11,830	....	....
10,000 to 99,999 acres	4	88,325	13.5	....	....	....	....	....	....	....	....	1	20,000	....	....
100,000 acres and over	1	100,000	15.3	....	....	....	....	....	....	1	100,000	....	....	....	....

TABLE 21.—CLASSIFICATION OF MINES ACCORDING TO ACREAGE, BY STATES AND TERRITORIES: 1902—Continued.

	IDAHO.		MARYLAND.		MONTANA.		NEVADA.		NEW JERSEY.		NEW MEXICO.		NORTH CAROLINA.		OREGON.	
	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.
Producing mines:																
Deep—																
Land owned—																
Total	111	19,246	......	......	110	14,980	67	8,253	......	......	61	15,072	9	3,580	68	9,397
20 acres or less	16	308	......	......	40	690	23	408	......	......	14	264	1	15	8	160
21 to 99 acres	42	2,365	......	......	33	1,745	17	941	......	......	25	1,428	1	55	24	1,367
100 to 999 acres	49	11,156	......	......	35	8,985	26	5,584	......	......	20	5,780	6	2,460	36	7,870
1,000 acres and over	4	5,417	......	......	2	3,560	1	1,320	......	......	2	7,600	1	1,050	......	......
Land leased—																
Total	15	581	1	120	44	1,533	7	308	......	......	15	782	1	643	4	160
20 acres or less	11	199	1	120	30	531	5	123	......	......	6	108	......	......	2	40
21 to 99 acres	2	58	......	......	10	562	1	85	......	......	8	414	......	......	2	120
100 to 999 acres	2	324	......	......	4	440	1	100	......	......	1	260	1	643	......	......
Placer—																
Land owned—																
Total	76	17,180	......	......	25	12,868	13	11,215	......	......	5	804	4	1,106	164	27,532
20 acres or less	18	220	......	......	3	60	6	60	......	......	......	......	1	13	27	526
21 to 99 acres	26	1,398	......	......	5	342	3	155	......	......	1	26	1	40	68	3,631
100 to 999 acres	35	10,262	......	......	14	4,866	1	320	......	......	4	778	2	1,053	65	17,035
1,000 acres and over	2	5,300	......	......	3	7,600	3	10,680	......	......	......	......	......	......	4	6,340
Land leased—																
Total	4	1,080	......	......	2	679	1	20	......	......	6	3,231	1	150	15	1,753
20 acres or less	......	......	......	......	......	......	1	20	......	......	1	20	......	......	3	60
21 to 99 acres	1	60	......	......	......	......	......	......	......	......	4	211	......	......	5	290
100 to 999 acres	3	1,020	......	......	2	679	......	......	......	......	......	......	1	150	7	1,403
1,000 acres and over	......	......	......	......	......	......	......	......	......	......	1	3,000	......	......	......	......
Development work without production:																
Owned and leased—																
Total	304	44,374	1	65	124	38,384	73	18,158	1	1,602	146	50,322	24	16,692	181	28,691
20 acres or less	42	802	......	......	33	577	13	249	......	......	12	189	1	8	12	211
21 to 99 acres	132	7,898	1	65	35	2,061	19	1,213	......	......	58	3,158	10	604	71	4,510
100 to 999 acres	125	26,094	......	......	54	9,086	38	11,287	......	......	75	14,700	9	3,310	96	20,870
1,000 acres and over	5	9,580	......	......	1	1,660	3	5,409	1	1,602	......	......	4	12,770	2	3,100
10,000 to 99,999 acres	......	......	......	......	1	25,000	......	......	......	......	1	32,185	......	......	......	......
100,000 acres and over	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

	SOUTH CAROLINA.		SOUTH DAKOTA.		TENNESSEE.		TEXAS.		UTAH.		VIRGINIA.		WASHINGTON.		WYOMING.	
	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.	Number of mines reporting.	Acreage.
Producing mines:																
Deep—																
Land owned—																
Total	2	3,150	32	12,257	......	......	1	620	62	12,711	1	275	20	2,256	4	448
20 acres or less	......	......	5	69	......	......	......	......	3	47	......	......	5	77	......	......
21 to 99 acres	......	......	11	566	......	......	......	......	32	1,933	......	......	9	411	2	100
100 to 999 acres	......	......	13	3,646	......	......	1	620	25	7,472	1	275	6	1,768	2	348
1,000 acres and over	2	3,150	3	7,976	......	......	......	......	2	3,259	......	......	......	......	......	......
Land leased—																
Total	......	......	3	192	......	......	......	......	19	1,158	2	133	1	20	......	......
20 acres or less	......	......	1	10	......	......	......	......	4	53	......	......	1	20	......	......
21 to 99 acres	......	......	1	55	......	......	......	......	12	661	2	133	......	......	......	......
100 to 999 acres	......	......	1	127	......	......	......	......	3	444	......	......	......	......	......	......
Placer—																
Land owned—																
Total	......	......	1	240	......	......	......	......	1	160	1	107	7	412	......	......
20 acres or less	......	......	......	......	......	......	......	......	......	......	......	......	3	52	......	......
21 to 99 acres	......	......	......	......	......	......	......	......	......	......	......	......	2	120	......	......
100 to 999 acres	......	......	1	240	......	......	......	......	1	160	1	107	2	240	......	......
1,000 acres and over	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Land leased—																
Total	......	......	......	......	1	80	......	......	......	......	......	......	1	60	......	......
20 acres or less	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
21 to 99 acres	......	......	......	......	1	80	......	......	......	......	......	......	1	60	......	......
100 to 999 acres	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1,000 acres and over	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Development work without production:																
Owned and leased—																
Total	......	......	111	41,116	......	......	......	......	251	37,292	3	2,276	138	25,290	83	16,614
20 acres or less	......	......	4	55	......	......	......	......	19	344	......	......	9	180	8	150
21 to 99 acres	......	......	30	1,847	......	......	......	......	86	4,773	......	......	51	3,104	31	2,009
100 to 999 acres	......	......	73	22,194	......	......	......	......	145	30,275	2	882	75	16,606	43	8,455
1,000 acres and over	......	......	3	5,880	......	......	......	......	1	1,900	1	1,394	3	5,400	1	6,000
10,000 to 99,999 acres	......	......	1	11,140	......	......	......	......	......	......	......	......	......	......	......	......
100,000 acres and over	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

The preceding table shows the concentration of the ownership of mineral lands, both in deep and placer mines. By far the greater part of all mineral lands is held in plots of 100 acres or more, representing an aggregation of five or more original locations. This concentration is especially conspicuous in mining properties which are now being developed; four-ninths of all such mineral lands are held by 52 operators. One mining property in California extends over an area of 100,000 acres.

The correlation between the area of mineral lands and value of production is shown in the following table:

TABLE 22.—*Classification of deep and placer mines by acreage and value of product: 1902.*

	Number of mines.[1]	ACREAGE.		VALUE OF PRODUCT AT MINE.			
		Total.	Per cent.	Total.	Per cent.	Average per mine.	Average per acre.
Deep and placer mines	2,937	406,009	100.0	$78,151,089	100.0	$26,609	[2]$188
20 acres or less	921	13,644	3.4	7,476,142	9.6	8,117	548
21 to 99 acres........	963	49,602	12.2	20,144,263	25.8	20,918	406
100 to 999 acres......	808	208,772	51.4	38,258,629	48.9	47,350	183
1,000 acres and over.	67	133,991	33.0	10,335,376	13.2	154,259	77
Acreage not reported	178	....	......	1,936,679	2.5	10,880	....
Deep mines ...	1,959	219,349	100.0	73,961,544	100.0	37,755	[2]330
20 acres or less	716	9,989	4.6	7,265,756	9.8	10,148	727
21 to 99 acres........	670	33,939	15.5	19,635,727	26.6	29,307	579
100 to 999 acres......	498	119,842	54.6	35,902,968	48.5	72,094	300
1,000 acres and over.	29	55,579	25.3	9,474,168	12.8	326,625	170
Acreage not reported	46	....	......	1,682,925	2.3	36,585	....
Placer mines..	978	186,660	100.0	4,189,545	100.0	4,284	[2]21
20 acres or less	205	3,655	2.0	210,386	5.0	1,026	58
21 to 99 acres........	293	15,663	8.4	508,536	12.1	1,736	32
100 to 999 acres......	310	88,930	47.6	2,355,661	56.2	7,599	26
1,000 acres and over.	38	78,412	42.0	861,208	20.6	22,663	11
Acreage not reported	132	....	......	253,754	6.1	1,922	....

[1] Exclusive of 55 custom mills.
[2] The product on which this average is computed does not include that for mines which do not report acreage.

It appears from the preceding table that the value of the mining product bore no direct relation to the area of mineral lands owned or leased. The average production per acre decreased as the area increased; the three owners of the largest acreage were among the smallest producers. It is probable that while the smaller properties were under active operation the larger were awaiting development. Still the value of the average production per mine increased with the increased ownership of mineral lands, though not in the same ratio.

The following table shows in parallel columns the royalties paid and the value of product of deep mines operated on leased land only. It covers 10,872 acres, i. e., 78 per cent of all lands leased by deep mines. Operators, 55 in number, who owned mineral lands in addition to the lands leased are omitted.

TABLE 23.—*Value of product and royalties of deep mines operating on leased land only: 1902.*

STATE OR TERRITORY.	Number of mines.	Value of product at mine.	RENT AND ROYALTIES FOR MINERAL LANDS.	
			Total.	Per cent of product.
United States	330	$3,240,986	$510,818	15.8
California..........................	30	188,547	18,195	9.7
Colorado	193	2,190,840	379,521	17.3
Georgia	5	6,099	731	12.0
Idaho	14	43,906	6,057	13.8
Montana..........................	40	389,445	72,275	18.6
Nevada	5	126,265	3,591	2.8
New Mexico	14	106,173	11,233	10.6
South Dakota..........................	3	54,234	6,271	11.6
Utah	16	111,145	5,460	4.9
All other states and territories[1]........	10	24,332	7,481	30.7

[1] Includes Arizona, 2; Maryland, 1; North Carolina, 1; Oregon, 3; Virginia, 2; and Washington, 1.

The following is a summary of all the statistics for deep mines operated on leased land only:

TABLE 24.—*Summary for deep mines operated on leased land only: 1902.*

Number of mines..	330
Number of owners working	139
Salaries..	$195,917
Wages	$1,504,855
Contract work..	$70,399
Work on share of product	$28,581
Rent and royalties of mines and mineral lands....................	$510,818
Other miscellaneous expenses	$110,132
Cost of supplies and materials..	$590,914
Ore sold and treated, short tons..	267,555
Value of bullion contents:	
Gold..	$2,716,755
Silver..	$1,187,171
Other metals	$601,386
Total gross value..	$4,505,312
Average per ton	$17
Value of product at mine	$3,240,986
Average per mine..	$9,821
Acreage leased	10,872
Average per mine	33

Mechanical power.—The total primary power used in gold and silver mines amounted to 195,805 horsepower, of which 122,354 was steam, 43,936 water, 4,060 gas or gasoline, and 8,003 other power, mostly compressed air. Of this total the rented horsepower aggregated 17,452, of which 14,469 horsepower was electric. In addition 750 electric motors, having a capacity of 32,003 horsepower, were reported owned by the operators. More than one-half of all rented electric power was reported from California, the rest was nearly all used in Colorado.

The use of water as a motive power was a marked feature in California, which reported nearly one-half of all waterpower used, viz, 21,517 horsepower. The total horsepower of steam engines in that state was 16,858, and the total electric power owned and rented was 18,961. Thus water and electric power held a more prominent place in California than steampower.

Nearly all the power reported was used in deep mines; comparatively little was used in placers. The latter utilized chiefly water and electric power. The following table shows the quantity and kind of power used in producing mines, deep and placer:

TABLE 25.—*Power used in producing mines: 1902.*

	Total.	Deep.	Placer.
Total horsepower	195,805	184,512	11,293
Owned:			
Engines—			
Steam—			
Number	1,925	1,805	120
Horsepower	122,354	118,833	3,521
Gas or gasoline—			
Number	198	189	9
Horsepower	4,060	3,940	120
Water wheels—			
Number	788	686	102
Horsepower	43,936	40,206	3,730
Other power—			
Number	156	150	6
Horsepower	8,003	7,588	415
Rented:			
Electric, horsepower	14,469	10,982	3,487
Other power, horsepower	2,983	2,963	20
Electric motors owned:			
Number	750	607	143
Horsepower	32,003	27,758	4,245
Supplied to other establishments, horsepower	323	223	100

Over one-fourth of all deep mines and the bulk of the placer mines had nò other motive power except hand and animal power. The aggregate product of the deep mines operated in this primitive way was very small, as compared with the total product of deep mines, being valued at only $1,730,469, or 2 per cent. In placer mining, however, the reverse was the case, the major part of the placer product of the United States being obtained without mechanical power.

The following table is a summary of deep mines which used no mechanical power. Regular producers are segregated from mines, the operations of which consisted mainly of development work, to which production was merely incidental:

TABLE 26.—*Deep mines using hand and animal power only: 1902.*

	Total.	Producing.	Developing and producing.
Number of mines	563	330	233
Number of owners working	319	250	69
Salaries	$135,991	$62,247	$73,744
Wages	$1,144,414	$616,835	$527,579
Contract work	$60,041	$21,206	$38,835
Work on share of product	$175,988	$172,900	$3,088
Miscellaneous expenses	$145,217	$113,959	$31,258
Cost of supplies and materials	$282,432	$149,858	$132,574
Ore sold and treated, short tons	116,435	101,528	14,907
Gross value of product	$2,485,978	$2,221,421	$264,557
Average per ton	$21	$22	$18
Value of product at mine	$1,730,469	$1,557,438	$173,031
Average per mine	$3,074	$4,719	$742

The following table is a comparative summary of placers according to the power used, whether mechanical or other:

TABLE 27.—*Placer mines using mechanical or other power: 1902.*

	Total.	Mines with mechanical power.	All other.
Number of mines	[1] 967	155	812
Salaries	$318,313	$204,191	$114,122
Wages	$1,769,612	$826,826	$942,786
Contract work	$19,816	$14,318	$5,498
Work on share of product	$73,517	$33,153	$40,364
Miscellaneous expenses	$271,844	$179,832	$92,012
Cost of supplies and materials	$781,236	$531,363	$249,873
Value of product at mine	$4,058,189	$2,115,722	$1,942,467
Average per mine	$4,197	$13,650	$2,392
Method of treatment:			
Dredging [2]	45	45	....
Hydraulicking	471	52	419
Other methods	451	58	393

[1] Does not include 8 mines with stamp mills.
[2] Includes 1 mine using electric elevator.

The following is a comparative table of steam engines and horsepower reported for 1902, 1889, 1880, and 1870. The previous censuses did not distinguish producing mines from those where the work was confined to development; the results for 1902, in Table 28, therefore, combine both classes of mines. While the total horsepower used shows a remarkable increase, the average power per engine has remained practically the same. In 1870 it was 44 horsepower; in 1880, 46 horsepower; in 1889, 40 horsepower; and in 1902, 55 horsepower.

TABLE 28.—*Steam engines and horsepower, by states and territories: 1870 to 1902.*

STATE OR TERRITORY.	1902		1889		1880		1870	
	Number of engines.	Horsepower.	Number of engines.	Horsepower.	Number of engines.	Horsepower.	Number of engines.	Horsepower.
United States.	2,890	158,363	1,362	54,822	525	24,206	107	4,743
Alabama	11	313	1	(1)	......	......	......	......
Arizona	212	9,306	60	1,030	17	369	......	......
Arkansas	1	65	......	......	......	......	......	......
California	482	19,933	266	8,633	80	2,333	39	1,253
Colorado	951	60,265	502	13,972	135	3,190	15	488
Georgia	62	1,651	7	283	11	196	......	......
Idaho	189	11,027	80	2,296	13	260	5	82
Maine	......	......	......	......	12	194	......	......
Maryland	8	135	1	(1)	......	......	......	......
Michigan	......	......	7	529	......	......	......	......
Montana	265	12,570	86	4,239	19	608	1	10
Nevada	73	4,188	139	11,048	161	14,863	44	2,780
New Hampshire	......	......	......	......	2	55	1	15
New Mexico	135	6,156	62	1,912	2	45	......	......
North Carolina	56	1,782	47	2,415	15	298	......	......
Oregon	89	2,726	16	1,796	3	100	......	......
South Carolina	9	450	4	210	......	......	......	......
South Dakota	114	13,766	41	2,969	13	250	......	......
Texas	1	25	2	66	......	......	......	......
Utah	187	10,875	24	2,829	34	1,261	......	......
Virginia	9	177	3	125	5	74	2	115
Washington	50	1,593	2	21	......	......	......	......
Wyoming	86	1,360	12	449	3	110	......	......

[1] Not reported.

The following table shows the machinery used at producing mines, deep and placer, as well as at those at which development work only was done:

TABLE 29.—MACHINERY, BY KINDS AND BY STATES AND TERRITORIES: 1902.

	HOISTS.						PUMPS.						POWER DRILLS.					
	Total.	Steam.	Gas or gasoline.	Compressed air.	Water.	Electric.	Total.	Steam.	Gas or gasoline.	Compressed air.	Water.	Electric.	Total.	Steam.	Gas or gasoline.	Compressed air.	Water.	Electric.
United States	2,013	1,551	210	108	68	76	1,332	1,105	39	97	42	49	3,341	262	6	2,970	10	93
PRODUCING MINES.																		
Total	1,249	968	84	91	50	56	840	663	21	84	30	42	2,499	167		2,297	4	31
Deep	1,203	945	83	90	33	52	769	617	18	82	20	32	2,487	167		2,288	1	31
Placer	46	23	1	1	17	4	71	46	3	2	10	10	12			9	3	
Alabama	2	2					7	7					10	6		4		
Arizona	58	57	1				76	67	8	1			95	8		85		2
Arkansas	2	2					3	3					4			4		
California	238	132	26	28	42	10	165	78	10	30	27	20	518	10		502	1	5
Colorado	541	463	28	21		29	251	234		11	1	5	925	66		840	3	16
Georgia	27	24		1	1	1	43	40		2		1	35	4		27		4
Idaho	69	33	4	31	1		52	43		4	1	4	264	10		252		2
Maryland	2	2					1	1										
Montana	99	91	1		4	3	91	83		1		7	80	14		65		1
Nevada	33	19	7	5		2	7	3			1	3	32	4		28		
New Mexico	42	29	11			2	17	16	1				42	4		37		1
North Carolina	11	11					16	16					9			9		
Oregon	24	18	2	2	2		16	16					31			31		
South Carolina	6	6					4	4					7			7		
South Dakota	22	20		2			44	18		25		1	247	14		233		
Tennessee							2		2									
Texas	1	1																
Utah	58	46	2	1		9	23	13		10			183	21		162		
Virginia	1	1					10	10										
Washington	11	9	2				10	10					7	5		2		
Wyoming	2	2					2	1				1	10	1		9		
DEVELOPMENT WORK WITHOUT PRODUCTION.																		
Total	764	583	126	17	18	20	492	442	18	13	12	7	842	95	6	673	6	62
Alabama	1	1																
Arizona	141	73	66	2			106	92	8	5		1	121	7	4	88		22
California	98	66	11	4	15	2	55	35	3	5	10	2	119	6		98	3	12
Colorado	215	187	12	3		13	109	102	2	2	1	2	246	24		207		15
Georgia	2	2					4	4					1	1				
Idaho	31	27	2	2			22	21	1				32	3		27		2
Montana	36	35		1			41	41					46	4		41	1	
Nevada	40	22	16			2	21	19	2				18	5		12		1
New Mexico	48	47	1				29	28	1				29	5	1	23		
North Carolina	11	10				1	12	10				2	13			8		5
Oregon	29	25	2		2		10	10					38			34		4
South Dakota	22	20	1	1			25	24		1			55	14		41		
Utah	45	31	10	2		2	24	24					59	5		53		1
Virginia	5	4	1				1	1					4	4				
Washington	19	14	2	2	1		16	14	1		1		37	11	1	23	2	
Wyoming	21	19	2				17	17					24	6		18		

The total number of hoists in producing mines reported was 1,249, of which number 968 were operated by steampower, the rest by other mechanical power. Aside from the 563 deep mines which used only hand and animal power, there were a number of mines which were reached by tunnels or adits at which hoists could be dispensed with. The following comparative table shows the number of steam hoists used at all deep mines, producing as well as those reporting development work without production, in 1902 and 1880:

TABLE 30.—*Steam hoists at deep mines, by states and territories: 1902 and 1880.*

STATE OR TERRITORY.	1902	1880
United States	1,528	425
Alabama	3	....
Arizona	130	17
Arkansas	2	....
California	191	71
Colorado	648	127
Georgia	23	6
Idaho	55	11
Maine	....	11
Maryland	2	....
Montana	122	19
Nevada	41	99
New Hampshire	....	2
New Mexico	76	2
North Carolina	20	10
Oregon	42	3
South Carolina	6	....
South Dakota	40	6
Texas	1	....
Utah	77	34
Virginia	5	4
Washington	23	....
Wyoming	21	3

The following table shows the pumps used in all deep mines, producing as well as those reporting development work without production, in 1902 and 1880:

TABLE 31.—*Pumps at deep mines, by states and territories: 1902 and 1880.*

STATE OR TERRITORY.	KIND OF POWER.					
	Total.		Steam.		All other.	
	1902	1880	1902	1880	1902	1880
United States	1,261	159	1,050	154	202	5
Alabama	7	....	7	....	....	....
Arizona	179	4	156	4	23	....
Arkansas	3	....	3	....	....	....
California	196	28	106	24	90	4
Colorado	359	25	336	25	23	....
Georgia	34	8	33	8	1	....
Idaho	66	3	57	3	9	....
Maine	....	9	....	9	....	....
Maryland	1	....	1	....	....	....
Montana	120	10	114	10	6	....
Nevada	28	32	22	31	6	1
New Mexico	45	1	43	1	2	....
North Carolina	26	10	24	10	2	....
Oregon	23	2	23	2	....	....
South Carolina	4	....	4	....	....	....
South Dakota	69	3	42	3	27	....
Utah	47	16	37	16	10	....
Virginia	10	4	10	4	....	....
Washington	25	....	23	....	2	....
Wyoming	19	4	18	4	1	....

The total number of pumps used in 1902 was 1,261, of which number 1,059 were operated by steam and 202 by other power. Of this number, 769 were used in producing deep mines, 71 in productive placers, and 421 in mines under development. Some mines are drained by tunnels. The total number of producing deep mines being 2,017, it is apparent that a great many mines were not troubled with water and could therefore dispense with pumping machinery.

A noteworthy feature is the development of the use of power other than steam for operating pumping apparatus. In 1880 there were in all 4 pumps operated by water and 1 by compressed air; in 1902 the number of pumps operated by compressed air had increased to 97, the number operated by water to 42, and in addition 49 were run by electric power and 39 by gas or gasoline.

The following table shows the number of power drills at all deep mines in 1902 and 1880, by states and territories:

TABLE 32.—*Number of power drills at deep mines, by states and territories: 1902 and 1880.*

STATE OR TERRITORY.	1902	1880
United States	3,329	257
Alabama	10	....
Arizona	216	1
Arkansas	4	....
California	631	16
Colorado	1,168	26
Georgia	33	....
Idaho	296	2
Maine	....	6
Montana	126	1
Nevada	50	195
New Mexico	71	....
North Carolina	22	....
Oregon	69	....
South Carolina	7	....
South Dakota	302	3
Utah	242	3
Virginia	4	4
Washington	41	....
Wyoming	34	....

The total number of power drills reported at producing mines in 1902 was 2,499, of which number 2,297 were operated by compressed air, 167 by steam, 31 by electricity, and 4 by water. Power drills were used in 353 mines. Among them were 5 placer mines, with a total of 12 drills, used in working ancient river beds by drifting; of the number reported, 5 were not in use during the year 1902. Comparison with the Tenth Census shows a remarkable progress in the use of power drills. In 1880 there were in all 257 power drills in use; in 1902 the number was 3,329.

The comparative results of working with power drills and by hand are shown in Table 33. Only deep mines are included; 26 mines using power drills furnished incomplete information on the subject and are therefore omitted.

TABLE 33.—*Comparison of power drills and hand power at deep mines: 1902.*

	All mines.	Mines using power drills.	Mines using hand power.
Number of mines	1,909	322	1,587
Number of drills used	2,358	2,358	....
Tons of ore mined in 1902:			
Total	9,966,406	7,340,536	2,625,870
Average per mine	5,220	22,797	1,655
Wages below ground	$24,268,800	$14,991,375	$9,277,425
Average wages per ton	$2.43	$2.04	$3.53

The preceding table shows that three-fourths of the total quantity of ore came from mines using power drills. The average product per mine with power drills was 22,797 tons, whereas the average per mine where no power drills were used was only 1,655 tons. The saving in labor below ground effected by the use of power drills, as compared with mining by hand, amounted to $1.49 per ton.

Of the machinery especially designed for placers, dredges were used in 44 mines. There were also 32 steam shovels in use, of which 21 were used in producing placer mines, and 11 in mines at which development work only was done.

The majority of deep mines have adopted mechanical power for conveying their ores to the reduction works; a very large number, however, still adhere to the old-fashioned way of carrying the ore in wagons. The former numbered 1,182 and the latter 925. The length of railroad tracks on the surface was 168 miles; underground, 945 miles. The number of locomotives was reported as 49. Of this mileage, 3 miles on the surface and 25 underground were reported for placer mines which were operated by drifting.

Water plants.—An abundant supply of water is one of the prime conditions of successful mining, especially in placers. The gold and silver mines were equipped with extensive water plants, which included 3,927 miles of ditches, flumes, etc.—2,992 miles for placer mines, or an average of over 3 miles per mine, and 935 miles for deep mines, or less than one-half mile per mine. The following table shows the length of water ditches, flumes, and pipes, by states and territories, for placer and deep mines:

TABLE 34.—*Water plants—length of ditches, flumes, pipes, etc., by states and territories: 1902.*

	All classes.		PRODUCING MINES.						Development without production.	
			Total.		Deep.		Placer.			
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Miles.*	*Feet.*	*Miles.*	*Feet.*	*Miles.*	*Feet.*
United States	4,606	325	3,926	4,771	935	289	2,991	4,482	679	834
Alabama	0	3,890	0	3,640	0	1,000	0	2,640	0	250
Arizona	113	4,254	58	1,129	57	1,129	1	......	55	3,125
Arkansas	*0*	*1,400*	*0*	*1,400*	*0*	*1,400*	......	......	......	......
California	1,939	1,477	1,706	3,119	335	3,332	1,370	5,067	232	3,638
Colorado	216	1,420	166	852	75	4,732	90	1,400	50	568
Georgia	113	1,265	77	4,445	33	325	44	4,120	35	2,100
Idaho	700	4,946	599	2,386	110	1,653	489	733	101	2,560
Montana	230	960	198	2,730	54	4,850	143	3,160	31	3,510
Nevada	62	4,330	36	1,600	35	3,180	0	3,700	26	2,730
New Mexico	47	3,042	43	4,862	24	4,822	19	40	3	3,460
North Carolina	1	1,600	1	1,300	0	1,300	1	0	0	300
Oregon	959	2,881	867	2,543	41	5,111	825	2,712	92	338
South Dakota	77	2,585	69	505	68	3,985	0	1,800	8	2,080
Tennessee	0	2,500	0	2,500	......	......	0	2,500	......	......
Utah	88	4,345	80	1,110	80	210	0	900	8	3,235
Virginia	1	4,360	0	4,640	0	2,000	0	2,640	0	5,000
Washington	20	4,490	7	1,470	3	2,000	3	4,750	13	3,020
Wyoming	30	3,380	12	1,500	12	1,500	......	......	18	1,880

Production.—The value of the total production of gold and silver mines in continental United States in 1902 was $82,482,052, of which $77,154,326 was produced by deep mines and $5,327,726 by placer mines. In determining the value of the product at mine, the method of valuation adopted in the mining industry was followed by the census. The value of the ore and bullion is determined in accordance with a well established trade custom, in the following manner: The ore is sampled and assayed, and the price per ton is determined in accordance with the assay contents. Gold, if exceeding in value $1 per ton, is paid for at the coining rate of $20.67 per ounce, or very often at the commercial rate of $20 per ounce; sometimes a further discount of 5 per cent is made, i. e., of $1 per ounce to cover losses in reduction. Silver is paid for at the New York market quotation, usually with a discount of 5 per cent for losses in smelting. Lead is paid for at the New York quotation, usually with a discount of 10 per cent for losses in smelting, and with a further reduction of 2 cents per pound of fine lead contents for freight to New York. Copper is paid for at a stipulated price, depending upon the New York quotation, but usually from 4 to 6 cents below the same; an allowance is made for iron and manganese, if present in sufficient quantities; no allowance is made for zinc, but on the contrary a penalty is charged if the percentage of zinc exceeds a fixed maximum. After the gross price per ton has thus been determined a stipulated charge per ton is deducted for sampling, assaying, and treatment, and the balance represents the value of the ore at which the total value of the shipment is computed.

The freight charges for carrying the ore from the mine to the works are borne by the mine operator. Usually the freight is paid by the buyer and deducted from the agreed value of the shipment, and a check for the balance is delivered to the mine operator. Thus, as a rule, the value of the ore at mine is not a speculative quantity, but an amount appearing on the books of the mine operator. Where the mine is situated at a distance from a railroad station, the operator usually hauls the ore to the station by his own teams, and the cost of haulage is included in the operating expenses. Where a number of mines are centered in one camp, haulage is more frequently done by teamsters who make a specialty of hauling ore from the mines to the railroad station and bringing back supplies to the mines. Under ordinary circumstances the hire per ton will not vary during the year and can be accurately stated. This is true even if no separate account of it is kept by the operator, in which case the cost of haulage is included in the amount reported for freight. When the ore is of a very low grade, or where the mine is located at a great distance from the railroad station, and the cost of haulage is paid by the mine operator, it sometimes happens that the value realized does not repay the cost of shipping. A few such cases were reported for 1902, and the value of the product was shown as a "net loss."

The value of bullion when sold to the United States mints or assay offices is determined by assay; gold contents are paid for at the coining rate of $20.67 per fine ounce, and the silver contents at a price fixed from time to time by the Director of the Mint; a small charge is made for smelting and refining. When bullion is sold to private parties, banks, bullion dealers, etc., it is usually sold at a net price per crude ounce; the difference between the coining value of the fine gold contents and that paid by the buyer represents the expenses of refining and marketing the bullion, commissions, interest, etc. When the bullion is shipped by express the cost of expressage is deducted by the Mint and the balance is paid to the depositor of the bullion. Frequently bullion is sent by registered mail or brought to the Mint or bullion dealer personally by the owner. The cost of transportation is insignificant as compared with the value of the bullion, and may be treated as a negligible quantity. Thus the value received by the operator for his bullion always represents the value at his mine or works.

The following table shows in detail the manner in which the above-stated total value of the mining product was obtained:

TABLE 35.—*Value of product at mine: 1902.*

Placer mines		$4,188,795
Deep mines and mills connected with same: Ore and bullion sold		71,588,036
Mills operating on old dumps and tailings		361,045
Custom mills: Ore and bullion sold		8,410,854
Amount earned by all mills for custom work		847,334
Estimated value of increase of stock of ore		1,888,408
Estimated product of small mines:		
Placer		1,138,181
Deep		495,654
Total		$88,918,307
LESS.		
Net loss reported by mines	$3,916	
Decrease of stock on hand, estimated value	26,215	
Cost of purchased ores	5,993,915	
Freight paid on purchased ores	412,209	
Total		$6,436,255
Net total		$82,482,052

The values shown for placer bullion and for ore and bullion produced by deep mines and mills represent the amounts reported by the operators. There is a separate item showing the product of the treatment of old dumps and tailings. This represents the output of mills which operated exclusively on old dumps and tailings. The treatment of ore from dumps and tailings, which was incidental to the operations of all mills, is included in their total output.

The ore and bullion sold by custom mills represent only the products of ores purchased by those mills. When the ore was merely treated for a stipulated compensation and the dressed ore (concentrate) or bullion was returned to the owner, the amount earned for the treatment of the ore only was considered as belonging to the production of the mill. The value of the ore or bullion itself was not included in the product of the mill, inasmuch as it would have been a duplication of the value received by the mine owner for his product. Moreover, it was only in exceptional cases that the mill operator was able to report the value of such ores, inasmuch as his charges were not dependent upon the value of the ore and he had no interest to keep an account of the same. On the contrary, the product of the purchased ores was always reported. In order to eliminate duplications, the cost of purchased ores and freight paid on the same are deducted in the preceding statement from the total value reported.

The increase and decrease of the stock on hand represent the differences between the value of the stock on hand at the beginning and at the close of the year. In accounting for the mining production of a given year these differences must be taken into consideration, inasmuch as the product actually sold or treated during the year does not represent the returns for the mining expenses incurred during the same year. In individual cases the difference may be considerable. The value of the increase or decrease of stock of ore is necessarily an estimate. The value was computed at this office, taking as a basis in each case the value reported by the operator for the marketed ore and assuming the average value per ton of the increase or decrease of stock on hand to have been the same as that of the marketed ore. The decrease of stock represented ore mined in previous years and marketed during the year 1902. Though the grade of that ore may have been different from that of the ore mined during this year, yet for statistical purposes the assumption of one average value for all ore treated was correct. Where there was an increase of the stock of ore, however, it would be often unsafe to assume the average value of the ore on the dumps to be the same as that of the ore actually sold or treated. The ore may have been sorted and the better grade sold, the ore left on the dumps being of a low grade which it would not pay to ship, or a few test shipments may have been made which did not represent the average grade of ore. In order to guard against such errors no estimate was made of the value of the increase of stock whenever the same exceeded the actual quantity sold, unless, upon a comparison of the returns for ore actually sold with the outlay for mining, it appeared probable that more paying ore had been mined than sold and that the ore on hand was merely awaiting treatment. In all doubtful cases inquiries were addressed to the operators, and these, as a rule, were answered promptly and satisfactorily.

Nor were any estimates made of the increase of the stock of ore in cases where the mine was equipped with a mill. When the expenses of the latter were not reported separately there was no basis for estimating the cost of milling the ore, and none but the gross value of the same could be estimated; moreover, the fact that the ore was not milled raised the presumption, at least in some cases, that it did not pay to treat it. Thus the value of the increase of stock of ore is probably rather underestimated than overestimated.

There were a number of small mines, deep and placer, from which no report could be secured. Their output was ascertained from the best available sources, such as assay offices, local bullion dealers, and other reliable persons who, through business intercourse with the miners, had acquired information which enabled them to estimate the output of such mines with reasonable accuracy. These estimates, however, as will be shown later, seem to be below the actual production of this class of mines.

The value thus computed represents the value of the product of gold and silver mines for 1902. It must be understood that many small operators keep no books or records, and the amounts reported by them are approximations.

Bullion contents.—As explained above, the bullion contents of the ore were figured in detail in every settlement between mine operators and ore buyers. The statements rendered by the latter to the former are, in all well managed mines, kept on file and entered in detail in the books of the company. The same is done with United States Mint bullion returns. Not in all cases, however, are accounts kept with such accuracy, even in some of the larger mines. In such cases the bullion contents reported were of necessity estimated. The approximations, however, may be taken as reasonably accurate, inasmuch as the treatment charges did not vary widely for the same mine, while the freight per ton could be regarded as a constant quantity. In some cases the value alone was reported for each of the metallic elements of the ore; the number of ounces of gold and silver, and the pounds of lead and copper were then computed on the basis of the average value reported in other cases.

The total quantity of gold bullion produced by mills connected with mines was 1,666,515 ounces with a gross value of $34,062,535, or an average value of $20.44 per ounce. This was the rate realized by the operator, the difference of 23 cents representing the cost of refining and marketing the bullion. The gross value of the product of mines connected with mills includes the sum of $520,727, which represents net value, the refining charges on the bullion produced not having been reported. At the above average rate the cost of refining the above quantity must have been about $5,207, which, being added to the gross value, would increase the production by 252 ounces. The quantity is too small to be considered.

The number of fine ounces of gold produced by arrastras was not reported. The gross value, the treatment charges, and the net value alone were reported. The quantity was estimated upon the basis furnished by the reports of mines connected with mills.

The total value of the ore at the mine includes $495,654 reported from small mines, whose owners could not be located, and the product had to be ascertained from the best available sources. The amount so ascertained may in some cases have represented the net value realized by the miner for his ore. In others the estimates were apparently based upon the assumption that the values represented the metallic contents of the ore. The number of fine ounces of gold reported apparently represent an estimate at the coining rate of $20.67 per ounce of gold, or at the current commercial rate of $20 per ounce, and at the rate of 50 cents per ounce of silver.

For all these mines the average rate per ounce of gold was $20.17, which left about 50 cents for the cost of refining and marketing. Wherever the estimated value in reality represented net proceeds, this computation resulted in an underestimate of the quantity. Where, however, it represented gross value of metallic contents, it resulted in an overestimate of the net value produced. However, the amount is so small in proportion to the production of the United States that the effect of it upon the total product may be regarded as a negligible quantity.

Most of the placer mines failed to report the number of fine ounces of gold. There were 150 mines, which reported the gross value of the bullion, the cost of refining and expressage, and the value at the mine, viz., gross value of the bullion contents, $1,621,723; cost of refining and expressage, $9,530; value at mine, $1,612,193. The average cost of refining, etc., amounted to six-tenths of 1 per cent of the value, or 12 cents per ounce, leaving $20.55 as the value realized per ounce of placer gold. All other placer mines from which reports were received numbered 825, with an aggregate product valued at $2,583,272 at the mine. The average value per mine was $3,131, whereas the output of mines reporting charges averaged $10,748 per mine. Apparently the records were more complete with the larger mines. The average shown by them was taken as representing the general condition, and the number of fine ounces where the value only was reported was estimated at the rate of $20.55 per ounce.

Tables 36 and 37 present the bullion contents and the total gross value of the product of the mines and mills for 1902. The product of custom mills is not included, inasmuch as it represents the contents of ore bought from mine operators by whom it was presumably reported.

It is true the quantity treated during the year by reduction works would not exactly coincide with the quantity of ore sold by mine operators to the same class of works during the same year. Still the error is considered immaterial, and in no other way could duplications be avoided.

TABLE 36.—BULLION CONTENTS OF THE PRODUCT OF GOLD AND SILVER MINES CLASSIFIED BY CHARACTER OF MINE: 1902.

	Total value.	GOLD.		SILVER.		LEAD.		COPPER.		Zinc—value.	Other metals—value.[1]
		Fine ounces.	Value.	Fine ounces.	Value.	Fine pounds.	Value.	Fine pounds.	Value.		
United States	$99,093,070	3,149,128	$63,774,881	42,746,064	$21,448,851	411,038,434	$12,311,239	14,028,863	$1,016,204	$340,686	$201,209
Placer mines	5,343,176	259,143	5,340,087	4,303	2,235	....	....	....	....	....	854
Deep mines: Total	93,749,894	2,889,985	58,434,794	42,741,761	21,446,616	411,038,434	12,311,239	14,028,863	1,016,204	340,686	200,355
Mines without mill connection	34,226,861	1,058,064	21,197,571	20,160,820	10,140,531	87,026,083	2,149,356	6,468,663	508,324	166,767	64,312
Mines combined with mills	59,027,379	1,815,482	36,924,616	22,317,525	11,175,262	322,708,401	10,109,749	7,559,660	507,790	173,919	136,043
Estimated product of small mines	495,654	15,539	312,607	263,416	130,823	1,303,950	52,134	540	90	....	....

[1] Includes allowance made for iron in ore, $73,941; quicksilver saved in reworking old tailings, $8,906; realized for old tailings whose contents could not be ascertained, $118,114; platinum, $198; osmiridium, $50.

TABLE 37.—BULLION CONTENTS OF THE PRODUCT OF GOLD AND SILVER MINES, BY STATES AND TERRITORIES: 1902.

STATE OR TERRITORY.	GOLD.		SILVER.		LEAD.		COPPER.		Zinc—value.	Other metals—value.
	Fine ounces.	Value.	Fine ounces.	Value.	Fine pounds.	Value.	Fine pounds.	Value.		
United States	3,149,128	$63,774,881	42,746,064	$21,448,851	411,038,434	$12,311,239	14,028,863	$1,016,204	$340,686	$201,209
Arizona	115,565	2,362,845	1,044,181	524,894	3,022,655	87,899	173,729	15,298	....	7
California	752,993	15,475,262	381,283	191,898	164,153	5,706	18,859	2,091	....	1,649
Colorado	1,321,215	26,400,438	13,531,856	6,846,886	81,001,564	1,827,993	5,196,124	386,158	335,436	131,868
Georgia	7,214	148,309	614	312	4,600	161	9,500	1,235	....	....
Idaho	72,854	1,487,064	7,093,951	3,565,921	208,093,202	7,122,835	71,476	7,481	....	10,558
Montana	165,382	3,346,181	3,766,347	1,898,893	6,046,582	189,179	660,296	57,869	....	4,534
Nevada	87,244	1,771,322	3,781,278	1,882,832	3,721,963	111,718	11,651	1,038	....	4,205
New Mexico	17,317	356,412	276,260	142,823	2,881,366	80,955	720,519	61,735	....	3,000
North Carolina	3,226	65,722	1,975	1,029	....	....	45,234	5,961	....	....
Oregon	89,004	1,827,935	112,920	58,046	....	....	....	....	....	96
South Carolina	6,749	139,389	226	113	....	....	....	....	....	....
South Dakota	351,357	7,171,241	535,041	278,725	50,401	1,769	787	67	....	....
Utah	146,698	2,976,188	11,406,273	5,666,160	105,811,397	2,873,740	7,120,148	477,181	5,250	45,292
Washington	11,004	219,895	381,440	181,848	83,185	2,937	540	90	....	....
Wyoming	229	4,737	....	....	4,200	147	....	....	....	....
All other states[1]	1,077	21,941	432,410	208,971	153,166	6,140	....	....	....	....

[1] Includes Alabama, Arkansas, Maryland, Tennessee, Texas, and Virginia.

Gold and silver as by-products of other ores.—The product of gold and silver mines does not include the precious metal contents of copper and iron ores. The refined product which is placed on the market includes, on the other hand, the precious metal contents of all ores, regardless of their source of production. In order to make the mining product comparable with the refined product the following table is presented, in which the gold and silver contents of all ores, as well as of placer bullion, are shown:

TABLE 38.—*Gold and silver contents of the product of all mines: 1902.*[1]

SOURCE OF PRODUCTION.	GOLD.	SILVER.
	Fine ounces.	Fine ounces.
Total	3,242,039	55,819,946
Gold and silver ores and placer bullion	3,149,128	42,746,064
Copper ores	92,911	11,452,280
Iron ores	....	1,621,602

[1] Not including Alaska.

The gold and silver contents of copper ores shown in the preceding table are included in the value reported elsewhere for the product of copper mines, and the silver contents of iron ores are included in the value reported for iron ores.

The argentiferous iron ores exemplify the difficulties attending every classification. Such of these as contain high values in silver, which permit of their working for that metal, were classed as silver ores. With most of these ores, however, their chief value lies in the fluxing qualities of their iron and manganese contents, yet the value received for them by the mine operator represents practically nothing but the value of their silver contents. With the exception of a small quantity, the disposition of which was not reported, all this ore was sold to the American Smelting and Refining Company, which settles for it in the following manner:

The producer of the ore is paid in full for its silver contents at the New York quotation; the percentages of iron and manganese are added together and the percentage of silica is deducted from the sum. If the difference is equal to 40 per cent of the weight of the ore no charge, as a rule, is made for smelting and freight. A bonus is paid for every "unit"—i. e., 20 pounds—over the 40 per cent basis, usually at 15 cents per "unit"—i. e., three-fourths cent per pound—or a deduction is made at the same rate for every unit short of the 40 per cent basis. The value of the product classed as iron ore is made up as follows:

	Value.
Silver (1,621,602 ounces)	$883,987
Allowance for other metals (copper, lead, iron, manganese)	66,716
Total gross value	950,703
Deductions	169,787
Value at mine	780,916

The average assay of silver was 7 ounces per ton, and the average gross value of the ore was $4.16 per ton; thus at the present price the value of the silver alone would not pay for the smelting of the ore but for the exceptionally low charge for smelting, viz, 74 cents per ton. The richness of the ore in iron and manganese is what makes such a low rate possible.

The following table is a summary of the mines producing argentiferous iron ore, not included in the statistics for gold and silver:

Table 39.—*Summary of mines producing argentiferous iron ore: 1902.*

Number of mines	17
Salaries	$36,580
Wages	$265,400
Contract work	$29,988
Work on share of product	$84,368
Rent and royalties	$85,474
Other miscellaneous expenses	$27,365
Cost of supplies and materials	$118,596
Ore sold, short tons	228,719
Gross value of bullion contents	$950,703
Average per ton	$4
Value of product at mine	$780,916

In the following table the gold and silver contents of all ores mined in 1902, including those in which the precious metals were merely by-products, are shown by states and territories:

Table 40.—*Gold and silver contents of all ores mined, by states and territories: 1902.*

STATE OR TERRITORY.	GOLD.		SILVER.	
	Fine ounces.	Value.	Fine ounces.	Value.
United States	3,645,769	$73,974,706	55,911,946	$28,214,854
Alaska[1]	403,730	8,345,800	92,000	48,760
Arizona	131,091	2,672,916	1,656,925	836,450
California	770,204	15,828,536	1,096,068	562,635
Colorado	1,321,930	26,414,800	15,173,061	7,740,227
Georgia	7,214	148,309	614	312
Idaho	72,868	1,487,362	7,094,558	3,566,238
Montana	197,535	3,990,359	13,441,950	6,833,963
Nevada	87,248	1,771,402	3,782,754	1,883,589
New Mexico	17,546	360,988	282,317	145,844
North Carolina	3,338	67,962	8,557	4,529
Oregon	89,026	1,828,176	112,920	58,046
South Carolina	6,749	139,389	226	113
South Dakota	351,357	7,171,241	535,041	278,725
Utah	178,591	3,500,413	11,782,147	5,847,997
Washington	11,028	220,375	390,440	186,348
Wyoming	229	4,737		
All other states[2]	1,085	21,941	462,368	221,078

[1] Estimate of the Director of the Mint.
[2] Includes Alabama, Arkansas, Maryland, Michigan, Tennessee, Texas, and Virginia.

Comparisons with the report of the Director of the Mint.—The Director of the Mint estimates annually, from the records of the United States mints and assay offices and from statements furnished by private refineries, the product of refined gold and silver from domestic ores. The methods followed in making these estimates are stated as follows:

In estimating the gold yield of the United States in any given year only that gold is looked upon as really produced that has been refined, made ready for the market, and the ascertained amount of domestic origin (which is comparatively insignificant) that has been exported to foreign countries for reduction.

It has been the custom of the Bureau of the Mint to make for every calendar year two independent calculations of the gold product of the country, and to take their mean as the closest approximation that can be had to the actual output of the mines. The first of these is based on the amount of gold put upon the market by private refineries during the year plus the fine gold contained in the unrefined bullion of domestic production deposited at the mints and assay offices of the United States plus the pure metal of domestic production contained in ores, copper matte, etc., exported to other countries for reduction. The second calculation is based on the known disposition made of the newly produced gold in any calendar year. Such gold is either deposited at the mints and assay offices of the United States, or exported from the United States in form of bullion, ores, or copper matte, or used in the industrial arts. If foreign gold bullion enters into any of the above items, its amount must, of course, be deducted.

The silver product of the United States in any given calendar year is estimated in precisely the same manner as the gold product, namely, by making two independent calculations of the same and taking their mean as the actual product.[1]

The variance between these two estimates is confined within narrow limits. The variances for 1902 are as follows: For gold, 61,029 ounces, or about 1.5 per cent of either calculation; for silver, 66,972 ounces, i. e., somewhat over one-tenth of 1 per cent.

[1] Report of the Director of the Mint on the Production of the Precious Metals, 1902, pages 13 and 14.

The precious metal contents of all ores mined in 1902, as ascertained by the census of mines and quarries in the continental United States, are collated in the following statement with the estimates of the Director of the Mint for the United States, exclusive of Alaska:

Precious metal contents, Bureau of the Census, and Mint returns: 1902.

	Product of mines reported by Census.	Refined product estimated by Director of the Mint.	DIFFERENCE.	
			Excess of mining product over refined product.	Excess of refined product over mining product.
Gold, fine ounces	3,242,039	3,466,270	....	224,231
Silver, fine ounces	55,819,946	55,408,000	411,946	....

It appears from the preceding statement that the output of silver reported to the Bureau of the Census slightly exceeds the estimate of the Director of the Mint, whereas the product of gold reported to the Bureau of the Census is 6 per cent below the estimate of the Director of the Mint. At the Eleventh Census the difference was as high as 13 per cent of the refined product. The decline of placer mining and of mining on a small scale generally, the settlement of the mining districts and the improvement of transportation facilities, together with the progress of statistical methods have all contributed to making the returns of the present census more complete than its predecessors. On the other hand, there can be no coincidence between mine returns and the refined product for the same year, inasmuch as a part of the mining product of one year is refined during the following year.

The Mint agents in their reports show the distribution of gold between placer and deep mines by states and territories. In the following table the reports of Mint agents are compared with the results of the Census:

TABLE 41.—*Comparative statement of the gold contents of the product mined, as reported to the Bureau of the Census, and by Mint officers and agents, by states and territories: 1902.*

STATE OR TERRITORY.	DEEP.		PLACER.	
	Census (fine ounces).	Mint officers and agents (fine ounces).	Census (fine ounces).	Mint officers and agents (fine ounces).
United States	2,982,896	3,191,561	259,143	321,410
Alabama	51	117	3	25
Arizona	130,578	199,140	513	2,100
Arkansas	484	....	....	....
California	587,834	612,559	182,370	205,478
Colorado	1,318,758	1,348,046	3,172	31,444
Georgia	3,934	4,130	3,280	1,035
Idaho	55,777	33,500	17,091	34,547
Maryland	119	94	....	37
Montana	178,246	191,229	19,289	21,626
Nevada	85,825	144,211	1,428	757
New Mexico	11,824	12,297	5,722	6,312
North Carolina	3,184	8,727	154	803
Oregon	63,632	77,086	25,394	11,798
South Carolina	6,749	7,257	....	226
South Dakota	351,308	345,715	49	....
Tennessee	8	....	275	7
Utah	173,580	192,157	11	....
Virginia	112	181	33	27
Washington	10,664	15,115	364	3,000
Wyoming	229	....	....	2,188

The sources of production as reported by Mint officers and agents are arranged under two heads only, "quartz" and placer. It is evident by comparison with the Director's estimate of the refined product that the designation "quartz" includes all deep mines.[1]

The difference between the two sources compared in the preceding statement amounts to 62,267 ounces for placers and 208,665 ounces for deep mines, in all 270,932 ounces. It must be borne in mind, however, that the quantities reported by Mint officers and agents exceed the Director's estimate of the gold product in the continental United States by 46,691 ounces.

The excess over the Census returns for placer mines is greatest in Colorado, where the Mint officers report 31,444 ounces, whereas the Census returns show only 3,172 ounces. It seems probable that Colorado is erroneously credited by the officers of the Denver mint with the placer bullion produced in adjoining states, but shipped to Denver to be deposited at the United States Mint. The placer product credited to Idaho by the United States Assay Office, at Boise, is 17,456 ounces in excess of the Census returns; on the other hand, however, the Census returns show an excess of 13,596 ounces over the Mint report for Oregon; it is very likely that the Oregon product found its way through bullion dealers to the Boise assay office.

The gold product of placer mines, as reported to the Bureau of the Census directly by producers, was valued at $4,204,995, which corresponds to the value of 203,757 fine ounces, as estimated above. In addition to this amount the unreported production of small mines was estimated by local men at $1,138,181, which corresponds to the value of 55,386 fine ounces. Most of the placer bullion ultimately finds its way to the mints and assay offices. The report of the Mint officers and agents should therefore be given preference over the estimates of other local men. The excess of the amount reported by Mint officers and agents over the aggregate output reported directly by producers to the Bureau of the Census, viz, 123,903 ounces, with a coining value of $2,561,075, represents the product of small mines.

The excess of the gold product of deep mines as reported by Mint agents over the Census returns is greatest in Arizona and Nevada, namely, in Arizona, 68,562 ounces, which is equal to 52.5 per cent of the Census returns, and in Nevada 58,386 ounces—i. e., 68 per cent of the Census returns.

The following comparative table shows the distribution of the silver production by states, as ascertained by the census of mines and quarries and as estimated by the Director of the Mint. The quantities reported by Mint agents are shown in a parallel column.

[1] Report of the Director of the Mint on the Production of the Precious Metals, 1902, page 16.

TABLE 42.—*Comparative statement of the silver contents of the product mined, as reported to the Bureau of the Census, and the product of silver refineries, as estimated by the Director of the Mint, by states and territories: 1902.*

[Fine ounces.]

	Census returns.	Estimate of the Director of the Mint.	Report of Mint agents.	Excess of Census returns over Mint estimates.	Excess of Mint estimates over Census returns.
United States	55,911,946	55,500,000	57,836,558	411,946	....
Alaska	[1] 92,000	92,000	89,388	....	....
Arizona	1,656,925	3,043,100	3,170,000	....	1,386,175
California	1,096,068	900,800	476,756	195,268	....
Colorado	15,173,061	15,676,000	15,800,958	....	502,939
Georgia	614	400	581	214	....
Idaho	7,094,558	5,854,800	5,942,714	1,239,758	....
Montana	13,441,950	13,243,800	13,629,737	198,150	....
Nevada	3,782,754	3,746,200	3,998,383	36,554	....
New Mexico	282,317	457,200	280,490	....	174,883
North Carolina	8,557	20,900	23,368	....	12,343
Oregon	112,920	93,300	109,463	19,620	....
South Carolina	226	300	580	....	74
South Dakota	535,041	340,200	351,000	194,841	....
Texas	432,385	446,200	446,166	....	13,815
Utah	11,782,147	10,831,700	12,678,037	950,447	....
Washington	390,440	619,000	721,450	....	228,560
Wyoming	....	5,000	5,200	....	5,000
All other states [2]	29,983	129,100	112,287	....	99,117

[1] Estimate of the Director of the Mint.
[2] Includes Alabama, Maryland, Michigan, Tennessee, and Virginia.

Table 42 shows that while the Census returns for the United States, as a whole, substantially agree with the estimate of the Director of the Mint, there is a wide variance between the results for some of the states. The estimate of the Director of the Mint is 1,239,758 ounces, or 17 per cent short of the product ascertained by the Census for Idaho. On the other hand, the Census returns for Arizona are 1,386,175 ounces, or 45.5 per cent of the estimate of the Director of the Mint. Considering that the Census returns for other states, as well as the total for the United States, are in substantial harmony with the Mint estimates, it is not probable that the canvass of mines in Arizona by Census agents should have failed to reach 45.5 per cent of the silver product of that territory. Were it so, the difference for Arizona would have to be added to the Census total for the United States, in which case the estimate of the Director of the Mint would be 1,798,121 ounces below the total production of the United States. The Mint estimate of the total production for the United States, however, is more likely to be approximately accurate than its apportionment among the several states and territories, wherein the estimates of the Bureau of the Mint often widely disagree with the reports of its agents.

With special reference to Arizona, it is further possible that the excess of the Mint estimates over Census returns, both for the gold and the silver product, represents to some extent the product of Mexican mines brought over the border and sold in the United States.[1]

The Census returns for the silver product of Nevada slightly exceed the estimate of the Director of the Mint. Inasmuch as the silver product of Nevada usually occurs in association with gold, it would seem that the canvass of gold and silver mines must have been fairly complete. It is therefore difficult to account for the wide divergence between the Census returns and the Mint estimate of the gold product of the state. The vastness of the area to be covered and the sparseness of the population may to some extent have affected the Census returns; yet, considering that the variance between the Census returns and Mint estimates for other states is confined within comparatively narrow limits, it seems probable that Nevada has been credited by the Bureau of the Mint and its agents with much of the gold bullion brought from other states to the Carson City assay office.

Placer bullion usually carries silver; the quantity of silver, however, is in most cases too small to be figured in the value of the product. There were only 40 placer mines which reported separately the value of silver, amounting in all to $2,235. The reports of Mint agents, which are summarized in the statement below, place the coining value of silver at $12,752, corresponding to a commercial value of $5,129, at 52 cents per fine ounce.

The amount reported by Mint agents does not include the states of Colorado, Idaho, and Nevada. With the addition of the amount reported to the Bureau of the Census from these 3 states—viz, $1,444—the total value of the silver recovered as a by-product of placer mining amounts to $6,573. The difference between the Census returns and the Mint agents' estimates amounts to $4,338, which does not materially add to the silver production or reduce the gold production of the United States.

Gold and silver contents of placer bullion, as reported by Mint agents: 1902.[1]

	FINE OUNCES.		VALUE.		
				Silver.	
	Gold.	Silver.	Gold.	Commercial.	Coining.
United States	321,410	9,863	$6,643,985	$5,129	$12,752
California	205,478	5,460	4,247,602	2,834	7,046
Montana	21,626	2,417	447,046	1,257	3,125
Oregon	11,798	1,032	243,886	537	1,334
Washington	3,000	750	62,016	390	970
South Appalachian states [2]	2,160	214	44,652	111	277
All other states and territories [3]	77,348	(4)	1,598,783	(4)	(4)

[1] Figures taken from the Report of the Director of the Mint on the Production of the Precious Metals for the Calendar Year 1902, pages 86, 144, 145, 184, 187, and 212. Where only coining values were reported, fine ounces have been computed from such at a rate for gold of $20.67+ and for silver of $1.29. Commercial values have been figured at a rate of $0.52 per fine ounce.
[2] Includes Alabama, Georgia, Maryland, North Carolina, South Carolina, Tennessee, and Virginia.
[3] Includes Arizona, Arkansas, Colorado, Idaho, Nevada, New Mexico, South Dakota, Utah, and Wyoming.
[4] Not reported; included with gold.

Comparison with smelter returns.—Argentiferous lead and copper ores are reduced by smelting. There were only 3 lead smelters combined with silver-lead mines and constructed for the treatment of their own ores. Their total product for 1902 was equal to 137,002 ounces of silver and 1,884,591 pounds of lead, which was but a fraction of 1 per cent of the total product of silver-lead

[1] Report of the Director of the Mint on the Production of the Precious Metals, 1899, page 83.

mines. The product of these smelters was shipped to eastern refineries. The bulk of the silver and lead produced reached the smelters and refineries either in crude state or after only a preliminary milling treatment. As shown further in Table 43, the former contained 26,270,578 ounces of silver and the latter 16,207,767 ounces, exclusive of 267,119 ounces which were produced by small mines and could not be classified. According to reports received by the Bureau of the Census from smelters and refineries, the production of refined silver in the United States in 1902 was made up as follows:

	Fine ounces.
Produced by lead smelters and refineries	78,896,284
Produced by copper smelters and refineries	9,781,532
	88,677,816
Less contents of foreign ores reported	28,926,235
Total	59,751,581

The silver contents of foreign lead ores smelted on the Pacific coast were not reported, but the bullion product of those smelters is included in the above total. The ores imported through San Francisco, Cal., and Puget Sound, Wash., were valued at $2,519,289.[1] Figured at the rate of 52 cents per ounce of silver, they contained 4,844,786 ounces, which leaves 54,906,795 ounces of domestic silver. The total reported by private smelters and refineries to the Director of the Mint was 55,087,074 ounces.[2] Thus in all about 55,000,000 ounces of silver were produced by private smelters and refineries, of which over 44,000,000 ounces were produced from domestic ores by lead smelters and refineries. The last quantity covers the contents of all silver bearing ores, which shows the close interdependence between silver mining and lead smelting. The total silver product of 1902 was accordingly distributed by character of ore, as follows:

	Value.	Per cent.
Total value	$28,448,004	100.0
From gold and silver ores and placer bullion	[1]6,062,979	21.3
From argentiferous lead ores	15,385,872	54.1
From argentiferous iron ores	883,987	3.1
From copper ores	6,115,166	21.5

[1]Includes product of old dumps and tailings.

The total lead contents of argentiferous ores mined in 1902, including copper ores, amounted to 411,590,504 pounds. The refined lead product reported to the Bureau of the Census by lead smelters and refineries was 475,588,419 pounds, which included the production of foreign ores smelted on the Pacific coast and not segregated in the reports from smelters. The imports of lead in ore and base bullion at Puget Sound and San Francisco were reported as 27,969,934 pounds,[3] which must be deducted from the total reported by the smelters; this leaves 447,618,485 pounds of lead.

A portion of this quantity was produced from nonargentiferous lead; the United States Geological Survey estimates the quantity of soft lead refined by desilverizers at 5,395 tons, which leaves 436,828,485 pounds of argentiferous lead. The excess over the contents of ores mined equals 25,237,981 pounds, or 12,619 short tons. During 1902 the stock of domestic lead was reduced by 42,138 tons;[4] it is probable that the excess of the smelter returns represents the product of ores mined during the previous year. The United States Geological Survey estimates the yield of lead from argentiferous ores for 1902 at 195,571 tons.[5] This is 5 per cent short of the product reported by mine operators; the difference is easily accounted for by losses in smelting.

SHIPPING AND MILLING ORES.

The product after leaving the mine is treated either at a mill connected with the mine or at a custom mill in the vicinity; or it is merely concentrated at the mine and the dressed ore shipped to a smelter; or it is shipped in the crude state. Table 43 shows the tonnage, bullion contents, and gross value, total and per ton, of all ore sold and treated, classified according to the method of handling the same. No information of this character being available for certain small operators, from whom no individual reports were received, their estimated product is not included in Table 43.

[1]Report of the Director of the Mint on the Production of the Precious Metals, 1902, page 314.
[2]Ibid., page 13.
[3]Commerce and Navigation of the United States, 1902, Vol. I, page 386.
[4]United States Geological Survey, "Mineral Resources of the United States," 1902, pages 211 and 212.
[5]Ibid., page 207.

TABLE 43.—TONNAGE TREATED AND BULLION CONTENTS OF ORES REDUCED AT MINE AND SHIPPED IN CRUDE STATE: 1902.

	Tons sold or treated.	GOLD.			SILVER.			
		Quantity.	Value.		Quantity.		Value.	
		Fine ounces.	Total.	Per fine ounce.	Total, fine ounces	Per ton, fine ounces.	Total.	Per fine ounce.
Aggregate	9,788,124	2,874,446	$58,122,187	$20.22	42,478,345	4	$21,315,793	$0.50
Mines and mills	8,232,753	1,815,482	36,924,616	20.34	22,317,525	3	11,175,262	0.50
Ore treated	7,978,906	1,666,515	34,062,535	20.44	16,207,767	2	8,153,607	0.50
Ore shipped	253,847	148,967	2,862,081	19.21	6,109,758	32	3,021,655	0.49
Mines without mill connection	1,555,371	1,058,964	21,197,571	20.02	20,160,820	13	10,140,531	0.50
Shipping ore	1,304,503	881,018	17,613,417	19.99	19,100,326	15	9,614,445	0.50
Milling ore	212,492	156,091	3,163,112	20.26	846,858	4	421,791	0.50
Concentrated ore	38,376	21,855	421,042	19.27	213,686	6	104,295	0.49

	LEAD.				COPPER.			Other metals—value.	Gross value—total.	Per cent.	Average gross value per ton.
	Quantity.		Value.	Cents per fine pound.	Fine pounds.	Value.	Cents per fine pound.				
	Total, fine pounds.	Per ton, per cent.									
Aggregate	409,734,481	2.09	$12,259,105	3.0	14,028,323	$1,016,114	7.2	$541,041	$93,254,240	100.0	$10.00
Mines and mills	322,708,401	1.96	10,109,749	3.1	7,559,660	507,790	6.7	309,962	59,027,379	63.3	7.00
Ore treated	259,346,816	1.62	8,384,860	3.2	4,475,952	341,581	7.6	309,962	51,252,545	55.0	6.00
Ore shipped	63,361,585	12.48	1,724,889	2.7	3,083,708	166,209	5.4	....	7,774,834	8.3	31.00
Mines without mill connection	87,026,083	2.80	2,149,356	2.5	6,468,663	508,324	7.9	231,079	34,226,861	36.7	22.00
Shipping ore	83,923,765	3.22	2,087,461	2.5	6,216,589	494,441	8.0	198,881	30,008,645	32.2	23.00
Milling ore	1,778,878	0.42	39,065	2.2	54,117	4,009	7.4	28,030	3,656,007	3.9	17.00
Concentrated ore	1,323,440	1.72	22,880	1.7	197,957	9,874	5.0	4,168	562,209	0.6	15.00

The preceding table brings out the economic reasons governing the method of handling the ore. Where there was a mill at the mine the average value of the ore was about $7 per ton; where there was no mill at the mine the average value was $22. In the absence of a mill at the mine only ore of a higher grade was mined. On the other hand, where the ore could be reduced at the mine, low-grade ore was advantageously mined and treated. Even where there was a mill at the mine a portion of the ore was shipped to smelters. The value of such ore in 1902 averaged about $30 per ton, whereas the average grade of the ore treated at the mine was $6 per ton. Where there was no mill belonging to the mine the bulk of the ore was shipped, the value of the average grade of shipping ore being $23 per ton. In some districts the proximity of custom mills permitted the treatment of ores averaging about $17 per ton.

Another consideration which determines the method of handling the ore was the nature of its metallic contents. Ore shipped in crude state from mines without mill connection contained considerable values in silver, viz, $9,614,445, averaging 15 ounces per ton, whereas ores treated at neighboring custom mills were valued chiefly for their gold contents, silver averaging only 2 ounces per ton. Lead was also an important element in shipping ores, averaging 3.22 per cent of the ore, whereas in milling ores it was only a fraction of 1 per cent.

At mines with mill connection the value of the ores treated was nearly all in their gold contents, silver averaging 2 ounces per ton and lead only about 1.62 per cent. The ores shipped contained a greater value in silver than in gold, the average tenor in silver being 32 ounces per ton. The lead contents were also valuable, averaging 12.48 per cent of the crude ore. In such cases the ores were sorted before treatment; ore rich in silver and lead was shipped to smelters, the rest being treated at the mine.

A portion of the ore treated at the mills was merely concentrated preparatory to shipping. This was notably the case with ores rich in lead. The product of the mills contained 259,346,816 pounds of lead, which had to be extracted by smelting.

The total quantity of ore concentrated was, according to reports, 1,820,589 tons; but much more was probably concentrated, as the reports on this subject are incomplete. All this ore was concentrated at plants belonging to the mines. Only 38,376 tons were concentrated for outsiders, they being producers whose mines were located in the neighborhood of concentrating plants.

Concentration of ores before shipping is one of the modern devices for the economical handling of ores. The quantity of concentrates produced was 206,330 tons; the quantity of crude ore treated to produce these concentrates was 1,820,589 tons, as stated; the average degree of concentration was accordingly 1 ton of concentrates to 9 tons of crude ore. This reduces the bulk of the ore to be shipped to one-ninth of its original weight; a large saving is thus effected in freight and treatment charges.

The prices which were paid for the metallic contents of the mining product varied in accordance with the condition in which it was marketed. Gold bullion, produced by amalgamating, cyaniding, and chlorination works connected with mines, sold at $20.44 per fine ounce; when the ore was reduced at custom mills, gold brought on an average $20.26 per ounce. Gold in ore brought from $19.21 to $19.99 per ounce. Silver was figured at 50 cents per ounce; a portion brought only 49 cents per ounce. Lead was disposed of at an average of 3 cents per fine pound; when sold as concentrates it averaged 3.2 cents per pound, while in the crude state it brought from five-tenths to 1 cent less. Copper brought from 5 to 8 cents per pound.

Charges for treatment and freight.—Charges for treatment and freight are governing factors in the working of mines. They are materially reduced when the ore is treated at the mine or concentrated. The total charges for treatment and freight reported from mines without a mill connection amounted to $11,050,789, of which $5,020,233 was treatment charges, $2,021,828 freight, and $4,008,728 could not be segregated, the charges and freight not being entered separately on the books of the operators. The total amount of treatment and freight charges reported from mines with mill connection was $10,277,686, of which $3,697,138 was treatment charges, $2,341,765 freight, and $4,238,783 could not be segregated.

The following table shows the treatment charges and freight, classified according to the method of handling the ore:

TABLE 44.—*Treatment charges and freight on the product of mines and mills: 1902.*

	Tons.	Gross value.	Treatment charges, including freight.	Average per ton.	Value at mine.
Total	9,788,124	$93,254,240	$21,328,475	$2.18	$71,925,765
Mines and mills, ores sold and treated	8,232,753	59,027,379	10,277,686	1.25	48,749,693
Mines without mill connection	1,555,371	34,226,861	11,050,789	7.10	23,176,072
Shipping ore	1,304,503	30,008,645	9,865,405	7.56	20,143,240
Milling ore	212,492	3,656,007	1,039,533	4.89	2,616,474
Concentrated ore	38,376	562,209	145,851	3.80	416,358

The greater part of the treatment and freight charges on the product of mills consisted of deductions on concentrates and on 253,847 tons of ore shipped in crude state (see Table 43). The refining charges on bullion may be estimated at 1 per cent of the value of the gold contents and at 4 cents per ounce of silver, which is the highest rate charged by the United States mints and assay offices. This rate makes a total of $369,246 on gold and $892,751 on silver—in all, $1,261,997, or, in round figures, about $1,200,000. This leaves somewhat over $9,000,000 for treatment and for freight on concentrates and crude ore.

The amount of freight varied for the several states and within the same state materially, according to the location of the mine. The treatment and freight charges set the limit to the working of certain grades of ore. Table 45 shows, by states and territories, the total tonnage of ores treated at outside reduction works, the total treatment charges, including freight, and the average per ton, and the highest and lowest freight rate per ton. The freight charges indicate the distances of the mines from railroad connections.

TABLE 45.—*Tonnage treated at outside works, treatment charges, and freight, by states and territories: 1902.*

STATE OR TERRITORY.	Total tons treated at outside works.	TREATMENT CHARGES, INCLUDING FREIGHT.		FREIGHT PER TON.			
				Shipping ores.		Milling ores.	
		Total.	Average per ton.	Highest.	Lowest.	Highest.	Lowest.
United States.	1,782,554	$13,167,148	$7.39	$50.00	$0.05	$18.00	$0.15
Arizona	9,120	132,041	14.48	50.00	1.00	1.25	0.75
California	22,415	91,656	4.09	36.00	0.20	15.00	0.30
Colorado	1,265,262	8,098,597	6.40	21.45	0.05	9.75	0.30
Idaho	11,893	229,663	19.31	40.00	2.00	13.04	0.50
Montana	56,806	628,273	11.06	11.00	0.50	3.75	0.39
Nevada	40,613	571,528	14.07	30.00	1.00	10.00	0.20
New Mexico	8,969	73,707	8.22	16.00	0.83	18.00	0.50
Oregon	1,174	5,212	4.44	12.00	3.63	2.50	0.15
South Dakota	115,242	310,340	2.69	15.00	0.30	2.25	0.75
Utah	219,817	2,822,665	12.84	23.70	0.70	....	......
Washington	8,869	82,275	9.28	10.00	1.00	....	......
All other states[1]	22,374	121,191	5.42	....	......	....	......

[1] Includes mines located in Alabama, Arkansas, Georgia, North Carolina, South Carolina, Texas, Virginia, and Wyoming.

The freight rates were higher on shipping ores than on milling ores; the highest freight from the mine to the mill, $18 per ton, was paid in New Mexico; the highest freight from the mine to the smelter, $50 per ton, was paid in Arizona.

Grade of ore.—In Table 46 the gold and silver contents of all ores mined in 1902, wherein the precious metals were the chief item of value, are classified by the grade of ore. There were a number of cases which did not lend themselves to such a classification. In many mines the ore is sorted, first-class ore being shipped and second-class ore being treated at the mine. Census schedules did not call for a separate statement for each class of ore, and an average for all grades would fail for the purpose of this classification. However, as eight-ninths of the total gold product of deep mines and four-fifths of the total silver product have been classified, the table answers the purpose.

TABLE 46.—GOLD AND SILVER VALUES CONTAINED IN THE PRODUCT OF PRECIOUS METAL MINES, CLASSIFIED BY GRADE OF ORE, BY STATES AND TERRITORIES: 1902.

VALUE PER TON.	GOLD, TOTAL VALUE.								
	United States.	Arizona.	California.	Colorado.	Montana.	Nevada.	South Dakota.	Utah.	All other states and territories.[1]
All grades	$51,260,409	$2,130,996	$10,737,252	$23,281,795	$2,843,318	$1,638,796	$5,541,429	$2,928,816	$2,158,007
Less than $10	21,199,278	1,144,418	6,870,540	2,850,590	950,143	408,023	5,385,198	2,367,292	1,223,074
$10 and over, but less than $20	9,253,394	699,220	2,197,654	4,279,398	817,146	283,968	144,306	401,865	429,837
$20 and over, but less than $50	17,004,150	252,980	1,405,758	13,741,412	707,851	344,874	10,625	156,011	384,639
$50 and over, but less than $100	2,477,129	31,103	109,983	2,041,776	149,989	52,039	1,300	3,648	87,291
$100 and over	1,326,458	3,275	153,317	368,619	218,189	549,892	....	....	33,166

VALUE PER TON.	SILVER, TOTAL VALUE.						RECAPITULATION, UNITED STATES.	
	United States.	Colorado.	Montana.	Nevada.	Utah.	All other states and territories.[2]	Gold, per cent.	Silver, per cent.
All grades	$17,331,199	$6,337,576	$1,817,211	$1,728,319	$4,763,260	$2,684,833	100.0	100.0
Less than $10	4,344,369	1,886,767	861,030	45,838	224,085	1,326,649	41.4	25.1
$10 and over, but less than $20	6,181,826	1,781,700	331,090	291,164	3,429,920	347,952	18.0	35.7
$20 and over, but less than $50	3,518,381	2,142,693	260,078	132,306	492,543	490,761	33.2	20.3
$50 and over, but less than $100	1,824,009	411,867	306,283	35,210	616,712	453,987	4.8	10.5
$100 and over	1,462,614	114,549	58,780	1,228,801	....	65,484	2.6	8.4

[1] Includes mines located in Alabama, Arkansas, Georgia, Idaho, New Mexico, North Carolina, Oregon, South Carolina, Virginia, Washington, and Wyoming.
[2] Includes mines located in Alabama, Arizona, California, Georgia, Idaho, New Mexico, North Carolina, Oregon, South Carolina, South Dakota, Texas, Virginia, and Washington.

It appears from the preceding table that little gold was produced in 1902 from ores worth over $50 per ton. About two-fifths of all gold produced was won from low-grade ores worth less than $10 per ton, and about the same share was obtained from ores worth $20 or over.

Considering the three principal gold producing states, Colorado, California, and South Dakota, and taking $20 per ton as the dividing line between high-grade ores and average or low-grade ores, it appears that in Colorado high-grade ores predominate, whereas in California and South Dakota the product was chiefly won from low-grade ores. In South Dakota practically all gold was derived from ores worth less than $10 per ton. Of the smaller gold producers, Utah also treated mostly low-grade ores.

Silver was likewise won mostly from ores averaging less than $20 per ton, but the lowest grade of ore, averaging less than $10 per ton, was not as conspicuous as in gold mining. A comparative study of Tables 45 and 46 will show the extent to which the distance of the mine from reduction works affects the grade of ore treated. In Arizona the highest cost of freight for shipping ore was $50 per ton. Very little gold, however, was produced from ores which could bear such a freight rate. In California the highest freight rate on shipping ores was $36 per ton, while two-thirds of all gold was derived from ores worth less than $10 per ton, and less than one-sixth was produced from ores worth from $20 to $50 and over. In South Dakota the highest freight rate on shipping ore was $15 per ton, but the bulk of the ore was worth less than $10 per ton, and the quantity of high-grade ore, which could bear the highest freight rate, was insignificant.

An examination of the average treatment charges, inclusive of freight, will show what portion of the gold and silver ores produced in each state must be treated at or near the mine and what portion can be shipped to distant works. Taking the United States as a whole, it appears that two-fifths of all gold and one-fourth of all silver are recovered from ores worth less than $10 per ton, which could hardly bear the average transportation charges of $7.39 per ton and can therefore be economically treated only at or near the mine. On the other hand, about two-fifths of all gold and silver are won from ores worth over $20 per ton, which could be profitably shipped to distant works for treatment.

The following comparative table shows the average grades of gold and silver ore mined in 1880 and 1902. The Tenth Census took no cognizance of the base metallic contents of gold and silver ores. To make the data of both censuses comparable the gold and silver contents only are considered in the table which follows:

TABLE 47.—TONS OF ORE TREATED, GOLD AND SILVER CONTENTS, TOTAL AND AVERAGE PER TON, BY STATES AND TERRITORIES: 1902 AND 1880.

STATE OR TERRITORY.	1902							
	Tons of ore treated.	Gold.		Silver.			Total value.	
		Fine ounces.	Value.	Fine ounces.	Value. Coining.	Value. Commercial.	Coining.	Commercial.
United States	9,787,804	2,889,985	$59,741,290	42,741,761	$55,261,678	$21,446,616	$115,002,968	$81,187,906
Arizona	341,268	115,052	2,378,336	1,044,181	1,350,043	524,894	3,728,379	2,903,230
California	2,325,100	570,623	11,795,824	380,189	491,554	191,329	12,287,378	11,987,153
Colorado	2,230,599	1,318,043	27,246,366	13,531,843	17,495,591	6,846,379	44,741,957	34,092,745
Idaho	1,283,777	55,763	1,152,724	7,091,436	9,168,659	3,564,613	10,321,383	4,717,337
Montana	542,028	146,093	3,020,010	3,766,220	4,869,421	1,898,828	7,889,431	4,918,838
Nevada	238,607	85,821	1,774,077	3,781,030	4,888,569	1,882,703	6,662,646	3,656,780
New Mexico	39,265	11,595	239,690	276,269	357,194	142,823	596,884	382,513
Oregon	60,034	63,610	1,314,935	112,654	145,653	57,910	1,460,588	1,372,845
South Dakota	1,686,187	351,308	7,262,181	535,041	691,765	278,725	7,953,946	7,540,906
Utah	897,866	146,687	3,032,289	11,406,273	14,747,899	5,666,160	17,779,688	8,698,449
All other states[1]	143,073	25,390	524,858	816,625	1,055,830	392,252	1,580,688	917,110

STATE OR TERRITORY.	1880								1902		1880	
	Tons of ore treated.	Gold.		Silver.[2]			Total value.		Average value per ton.		Average value per ton.	
		Fine ounces.	Value.	Fine ounces.	Value. Coining.	Value. Commercial.	Coining.	Commercial.	Coining.	Commercial.	Coining.	Commercial.
United States	1,884,426	972,583	$20,105,073	30,577,025	$39,533,037	$34,674,346	$59,638,110	$54,779,419	$11.75	$8.29	$31.65	$29.07
Arizona	25,728	8,725	180,366	1,716,176	2,218,844	1,946,144	2,399,210	2,126,510	10.93	8.51	93.25	82.65
California	435,300	402,470	8,319,786	828,536	1,071,215	939,560	9,391,001	9,259,346	5.28	5.16	21.57	21.27
Colorado	330,581	110,181	2,277,649	12,579,551	16,264,101	14,265,211	18,541,750	16,542,860	20.06	15.28	56.09	50.04
Idaho	28,030	28,690	593,073	344,969	446,010	391,195	1,039,083	984,268	8.04	3.67	37.07	35.11
Montana	86,577	30,570	631,946	2,177,760	2,815,627	2,469,580	3,447,573	3,101,526	14.56	9.07	39.82	35.82
Nevada	346,331	206,907	4,277,156	8,964,562	11,590,282	10,165,813	15,867,438	14,442,969	27.92	15.33	45.82	41.70
New Mexico	7,452	2,388	49,354	303,455	392,337	344,118	441,691	393,472	15.20	9.74	59.27	52.80
Oregon	13,772	8,286	171,276	13,880	17,946	15,740	189,222	187,016	24.33	22.87	13.74	13.58
South Dakota[3]	496,130	151,837	3,138,751	54,577	70,563	61,890	3,209,314	3,200,641	4.72	4.47	6.47	6.45
Utah	93,117	13,063	270,045	3,555,538	4,596,954	4,031,980	4,866,999	4,302,025	19.80	9.69	52.27	46.20
All other states[1]	21,408	9,466	195,671	38,021	49,158	43,115	244,829	238,786	11.05	6.41	11.44	11.15

[1] Includes Alabama, Arkansas, Georgia, Maryland, North Carolina, South Carolina, Tennessee, Texas, Virginia, Washington, Wyoming, Maine, New Hampshire, and Michigan.
[2] The commercial value of an ounce of silver for the census year 1880 was obtained by taking the average between the prices for 1879 and 1880, which is $1.134.
[3] In 1880 formed part of the territory of Dakota.

As appears from Table 47, in all states and territories, except Oregon, the grade of ore has considerably decreased, while at the same time the quantity of ore mined and the total gold and silver values show everywhere a remarkable increase. This fact furnishes unmistakable evidence of the progress of gold and silver mining since the Tenth Census. The development of transportation facilities and improvement of mining methods and reduction processes have enabled the mine operators to handle large masses of low-grade ore which could not have been profitably mined two decades ago.

Classification of mines by metals produced.—In Table 48 all deep mines are classified into two groups—(1) gold and silver mines and (2) argentiferous lead mines. The ore mined from the former is valued chiefly for its gold contents, though it carries considerable values in silver and small quantities of other metals. The mines of the latter class yield lead ores rich in silver and associated with gold and other metals.

The total gold contents of the ores of both classes were valued at $57,829,542, of which $5,734,677, or about one-tenth, was carried by argentiferous lead ores and $52,094,865 by gold and silver ores. The latter can again be divided into two portions; about one-half, valued at $26,898,810, carried considerable values in silver, the rest, valued at $25,136,100, was produced from mines which reported no value for silver. It is probable that in many cases this gold was likewise associated with silver, but the percentage of silver saved was too small to be of commercial value.

The silver-lead mines include also those which reported no values other than those for silver. The total product of such mines was valued at $430,281. It is probable, however, that some of this silver was associated with lead, but the percentage of the latter was below the 5 per cent limit paid for by the smelters.

The value of the product shown in Table 48 is only that of the ore actually sold or treated. Ore mined but not sold or treated is not taken into consideration for the following reason: Gold and silver ores are mostly reduced at mills connected with the mines. It will be remembered that in such cases the value of the increase or decrease of the stock of ore was not estimated. Argentiferous lead ores, on the contrary, are all shipped to smelters, so that the value of the increase or decrease of the stock was oftener estimated for this class of ore than for gold and silver ores. In order to avoid artificial disproportion in the results obtained, the total value of the product at the mine includes only the value of the ore sold or treated and the amount received from custom work, less the cost of purchased materials.

TABLE 48.—*Summary of deep mines, classified by metals produced: 1902.*

	Total.	Gold and silver.	Argentiferous lead.
Number of mines[1]	1,935	1,488	447
Salaries	$4,569,362	$3,270,427	$1,298,935
Wages	$33,582,274	$24,653,242	$8,929,032
Contract work	$606,137	$440,993	$165,144
Work on share of product	$1,375,843	$1,348,059	$27,784
Miscellaneous expenses	$4,779,249	$3,693,066	$1,086,183
Cost of supplies and materials	$15,095,534	$11,796,089	$3,299,445
Cost of purchased ores, including freight	$13,789	$13,789	....
Ore sold and treated, short tons	9,662,050	7,052,236	2,609,814
Ore purchased, short tons	967	967	....
Value of bullion contents:			
Gold	$57,829,542	$52,094,865	$5,734,677
Silver	$21,215,701	$5,829,829	$15,385,872
Lead	$12,258,530	....	$12,258,530
Other metals	$1,552,058	$448,272	$1,103,786
Total gross value	$92,855,831	$58,372,966	$34,482,865
Average per ton	$10	$8	$13
Treatment charges and freight	$21,271,711	$10,027,089	$11,244,622
Value of product at mine	$71,584,120	$48,345,877	$23,238,243
Amount received for custom work	$529,020	$487,937	$41,083
Total value at mine	$72,099,351	$48,820,025	$23,279,326
Average per mine	$37,260	$32,809	$52,079

[1] Does not include 55 custom mills and 27 mills run on old dumps and tailings.

The following table presents a classification of all dividend paying productive deep mines by metals produced:

TABLE 49.—*Dividend paying productive deep mines, classified by metals produced: 1902.*

	Total.	Gold and silver.	Argentiferous lead.
Number of mines[1]	100	71	29
Salaries	$1,358,783	$857,821	$500,962
Wages	$10,096,917	$6,707,061	$3,389,856
Contract work	$165,135	$105,793	$59,342
Work on share of product	$202,754	$194,754	$8,000
Miscellaneous expenses	$1,747,144	$1,040,099	$707,045
Cost of supplies and materials	$4,730,536	$3,572,962	$1,157,574
Ore sold and treated, short tons	3,163,498	2,039,925	1,123,573
Value of bullion contents:			
Gold	$24,382,754	$22,560,052	$1,822,702
Silver	$11,066,762	$2,469,000	$8,597,762
Lead	$6,849,001	....	$6,849,001
Other metals	$561,171	$89,997	$471,174
Total gross value	$42,859,688	$25,119,049	$17,740,639
Average per ton	$13.55	$12.31	$15.79
Treatment charges and freight	$9,514,541	$3,840,162	$5,674,379
Value at mine	$33,345,147	$21,278,887	$12,066,260
Amount received for custom work	$58,638	$58,638	....
Total value of product at mine	$33,403,785	$21,337,525	$12,066,260
Average per mine	$334,038	$300,529	$416,078

[1] Does not include 2 mills run on old dumps and tailings.

DEEP MINES.

Mines with and without reduction works.—The majority of deep mines had no reduction works to treat their ores; about one-third of the total number were equipped with reduction works. The latter, however, contributed about two-thirds of the product of gold and silver mines. The average production of a mine which had no mill was $18,178, whereas the average for the 585 mines equipped with reduction works was $86,381. The average grade of ore treated by the former was worth $22, whereas the latter treated low-grade ore worth less than $10 per ton, viz, 316 mills treated ore averaging $8.65 per ton and 269 treated ore averaging $5.43 per ton. About one-half of the mines connected with mills furnished separate reports for the mine and the mill. A number of operators, however, kept only one account for both mine and mill, and so reported them.

The following table is a comparative summary of mines with and without reduction works; mines and mills for which distinct reports were furnished are presented under a separate head:

TABLE 50.—*Deep mines with and without mill connection: 1902.*

	Deep mines without mill connection.	Mines and mills reported jointly.	MINES AND MILLS REPORTED SEPARATELY.	
			Mines.	Mills.
Number of mines[1]	1,275	316	269	....
Salaried officials, clerks, etc.:				
Number	1,198	887	793	226
Salaries	$1,557,458	$1,441,006	$1,262,685	$306,978
Wage-earners:				
Average number	10,485	9,969	10,648	1,897
Total wages	$10,779,143	$10,155,216	$10,672,005	$1,951,155
Contract work	$387,117	$98,518	$120,502	....
Work on share of product	$1,239,379	$80,504	$53,790	....
Miscellaneous expenses	$1,922,388	$1,644,418	$1,028,476	$181,283
Cost of supplies and materials	$4,475,604	$4,074,787	$4,486,299	$2,050,097
Crude ore shipped, short tons	[2] 1,555,371	253,847	....	....
Ore treated, total, short tons	....	2,544,142	....	5,368,143
Mined and treated	....	*2,500,282*	....	*5,348,806*
Purchased ores	....	43,860	....	967
Custom ores	....	....	....	18,370
Value of bullion contents:				
Crude ore shipped—				
Gold	$21,197,571	$2,862,081	....	....
Silver	$10,140,531	$3,021,655	....	....
Lead	....	$1,724,889	....	....
Other metals	$2,888,759	$166,209	....	....
Total gross value	$34,226,861	$7,774,834	....	....
Average per ton	$22	$31	....	....
Treatment charges and freight	$11,050,789	$2,918,660	....	....
Value at mine	$23,176,072	$4,856,174	....	....
Ore treated—				
Gold	....	$14,158,166	....	$19,485,002
Silver	....	$3,686,212	....	$4,366,205
Lead	....	$3,519,700	....	$4,864,585
Other metals	....	$270,624	....	$375,822
Total gross value	....	$21,634,702	....	$29,091,614
Average per ton	....	$9	....	$5
Treatment charges and freight	....	$3,387,791	....	$3,820,678
Value at mine	....	*$18,246,911*	....	*$25,270,930*
Amount received for custom work	....	[3] $402,206	....	$42,740
Cost of purchased ores, including freight	....	....	....	$13,789
Total value of product at mine	....	$23,505,291	....	$25,299,887
Average per mine	$18,178	$74,387	....	$94,052

[1] Does not include 48 arrastras, nor 27 mines whose product was reduced in hand mortars.
[2] Includes ore treated at custom mills.
[3] Includes $254,797 charged by reduction works against their own mines and credited by the latter to their reduction works.

Arrastras.—The primitive Mexican arrastra, in its old-fashioned form or somewhat modernized, has survived in a few small mines. The total number of mines reporting arrastras was 47, viz, 36 in California, 6 in Oregon, 3 in Idaho, 1 in Arizona, and 1 in New Mexico. At 23 no hired labor was employed.

The total value of the product of all such mines was $77,818, the average per mine being $1,655. The average tonnage treated was 75 tons per mine. A summary of mines with arrastras is presented in the following table:

TABLE 51.—*Summary for arrastras: 1902.*

Number of mines	47
Number of owners working	57
Salaries	$250
Wages	$16,388
Work on share of product	$2,170
Miscellaneous expenses	$956
Cost of supplies and materials	$5,228
Ore treated, short tons	3,502
Value of bullion contents:	
Gold	$78,298
Silver	$1,086
Total gross value	$79,384
Average per ton	$22
Treatment charges and freight	$1,566
Value at mine	$77,818
Average per mine	$1,655

Ore treated by hand.—Even the crudest form of treatment of ore in a hand mortar was found in a few cases. As a survival of archaic methods of production these mines well deserve notice. The 28 mines at which the ore was treated in such manner were distributed among the following states: California, 19; Oregon, 8; and Maryland, 1. The total output of these mines aggregated $48,280, averaging $1,724 per mine. There were 36 owners working in the mines, only 6 of which were operated with hired labor. The average quantity thus treated was less than 9 tons per mine, but the average value per ton was $200. There was evidently no regular production, but in every case a rich strike had been found by men of small means, who had no other facilities for treating their ore. A summary of these mines is presented in the following table:

TABLE 52.—*Summary for mines where the ore was treated in hand mortars: 1902.*

Number of mines	28
Number of owners working	36
Salaries	$985
Wages	$8,367
Miscellaneous expenses	$1,728
Cost of supplies and materials	$3,519
Ore treated, short tons	242
Bullion contents—	
Quantity—	
Gold, fine ounces	2,399
Silver, fine ounces	23
Value—	
Gold	$48,424
Silver	$12
Total gross value	$48,436
Average per ton	$200
Value of product at mine	$48,280
Average per mine	$1,724

Custom mills.—The following is a summary for mills which were operated independently of mines on purchased or custom materials. It comprises 24 mills in Colorado, 10 in California, 9 in Nevada, 4 in Idaho, 3 in New Mexico, and 1 each in Arizona, Montana, Oregon, South Dakota, and Utah.

TABLE 53.—*Summary for custom mills: 1902.*

Number of mills	55
Salaried officials, clerks, etc.:	
Number	65
Salaries	$141,126
Wage-earners:	
Average number	684
Wages	$578,101
Miscellaneous expenses	$254,980
Cost of supplies and materials	$723,807
Cost of purchased ore	$5,951,048
Freight on purchased ore	$411,504
Ore treated, short tons:	
Total	533,730
Purchased ore	352,316
Custom ore	181,414
Value of bullion contents of purchased ore:	
Gold	$8,332,350
Silver	$102,029
Total gross value	$8,434,379
Average per ton	$24
Treatment charges and freight	$23,525
Value of product at mill	$8,410,854
Amount received for custom work	$289,205
Total value at mill	$8,700,059
Average per mill	$158,183

Among the 55 mills comprised in the preceding summary there were 7 which were operated without hired labor; the number of owners personally working in their mills was 15. The time in operation was reported by 45 custom mills; the data furnished by them are included in Tables 17, 18, and 20. Of this number, 12 ran more than three hundred days during the year and 7 from two hundred and seventy-one to three hundred days; these 19 mills may be taken as representing all that were in continuous operation throughout the year, except on holidays and when stoppages were necessary for repairs, etc. Of the other 26 mills, operated only part of the year, 11 ran from ninety-one to two hundred and seventy days and 15, ninety days or less; that is, only during the busiest season.

The majority, when working, ran more than one shift, viz: 25 ran two shifts and 7 three shifts, while 13 ran only one shift. When two or three shifts were run the mill was operated uninterruptedly during twenty-four hours, making either twelve or eight hours per shift, except in 2 mills, where two shifts of eight hours each were run. Of the 13 mills running only one shift 7 were working twelve hours per day, 5 ten hours, and 1 eight hours. On the whole, twelve hours per shift was the working time in 30 mills, ten hours in 5 mills, and eight hours in 10 mills.

The total capacity of all custom mills per twenty-four hours was 2,892 tons. Two mills which treated during the year 350 tons failed to report their daily capacity. The total tonnage treated by all mills reporting their capacity was 533,380 tons. It required accordingly 184 days of twenty-four hours to handle that quantity of ore. This fact shows that the mines provided a sufficient supply of ore to keep the custom mills in continuous operation every day in the year with one working shift of twelve hours per day, including Sundays and holidays.

The total value at mill in Table 53 is $8,700,059. In computing the total value of the product shown in Table 35 for all mines and mills in the United States, the value of purchased materials was deducted in order to prevent duplications. The mills handled practically only gold ore of a high grade, averaging $24 per ton. About two-thirds of the ore treated at custom mills was purchased by them, and only about one-third was treated for customers at a stipulated rate per ton, the product being returned to the customers. Some custom work was occasionally done at mills connected with mines; it was only as an exception, however, that ore was purchased at such mills. In the statement which follows, the quantities of ore purchased and treated for a stipulated compensation per ton are summarized for all mills, those connected with mines as well as custom mills:

Tons of ore bought and treated for a stipulated compensation: 1902.

CHARACTER OF REDUCTION WORKS.	Purchased ore.	Custom work.
Total	353,283	243,644
Custom mill	352,316	181,414
Connected with mine	967	62,230

The reports from mines whose ore was treated at custom mills show 212,492 tons reduced to bullion and 38,376 tons concentrated and shipped to smelters for reduction; in all, 250,868 tons. The mine operators reported 7,224 tons, or 2.9 per cent more than was traced to mills.

There are many reasons why the returns from establishments representing successive stages of production can not exactly coincide. Among other things, the census was taken in the spring and summer of 1903 for the calendar year 1902. Some of the mills which had been in operation a few months in the early part of the year 1902 were idle or dismantled at the time the census was taken and their owners could not be located. Still, the preceding comparison shows that the omission was not material.

Mills in 1902 and 1880.—The following statement presents the comparative data relating to mills for 1902 and 1880. Making allowance for the incompleteness of the Tenth Census, the statement shows a remarkable increase both in the number of reduction works and the total quantity of ore treated by them. The average turnover per mill has also increased.

Production of mills: 1902 and 1880.

YEAR.	Number of mills.	TONS TREATED.	
		Total.	Average per mine.
1902	640	8,444,967	13,195
1880	169	1,367,479	8,083

METHODS OF TREATING THE ORE.

Of the 585 reduction works connected with deep mines, 456 were stamp mills, in which the ore was reduced by amalgamation; 83 were equipped with cyaniding plants, 16 with chlorination plants, and 301 with concentrators. Of the 55 custom mills, 46 were stamp and amalgamation mills, 10 were equipped with cyaniding, 5 with chlorination, and 21 with concentrating plants. There were, moreover, 27 mills which were run mainly on old mine dumps and mill tailings, though occasionally doing custom work. Of these, 16 were cyaniding works, 4 were stamp mills, and 7 were concentrating plants.

A difference in methods of transacting business among the various classes of custom mills deserves to be noted. Where the ore is treated by amalgamation, with or without concentration of the tailings, the mill operator, as a rule, does the work for the customer's account for a stated compensation and returns the product to the mine owner. At chlorination and cyaniding works, on the contrary, the ore is bought outright.

The relative place held by each class of mills in the gold and silver mining industry is shown by a comparison of the gross values of the ores treated by them. It should be noted that some cyaniding and chlorination works were also equipped with stamp mills and concentrating plants where a portion of the ore was treated.

Method of treating ore, by classes of mills: 1902.[1]

CHARACTER OF PROCESS.	Total.	Mills connected with mines.	Custom mills.
Total	$58,070,917	$49,636,538	$8,434,379
Amalgamation	3,260,246	3,260,246	....
Concentration	14,248,871	14,248,871	....
Amalgamation and concentration	14,103,276	14,102,176	1,100
Cyaniding, alone or in combination with other processes	16,588,667	15,674,687	913,980
Chlorination, alone or in combination with other processes except cyaniding	9,869,857	2,350,558	7,519,299

[1] Exclusive of mills operating only on old dumps and tailings.

Amalgamation and concentration.—Table 54 is a summary for amalgamation mills and concentrating plants. Where the ore was treated only by amalgamation its chief value consisted in its gold contents, though considerable values in silver were also saved. The values shown for "other metals" were realized from the sale of the tailings. The average grade of ore treated was worth only $6 per ton. A small quantity of high-grade ore averaging $68 per ton was shipped in crude state.

Where the ore was merely concentrated its main value was in its base metal contents (practically all lead). The ore averaged in crude state for one group of mills $11 per ton, and for another $7, and had to be concentrated before it could be shipped. High-grade ore was sorted out before concentrating and shipped in crude state; such ore shipped from the same class of mills averaged $28 and $43 per ton, respectively.

Where amalgamation was supplemented by concentration the chief value was in gold. These mills from which complete reports were received showed some values for silver and base metals; where the accounts were not kept separately for the mine and mill the total value was reported as gold, though in all probability it included some silver and base metals.

There was also a marked difference in the volume of production according to the character of the process applied: The value of the average product per mine with stamp mill (amalgamation) was a little over $15,000; the average per mine with stamp mill and concentration plant was over $50,000, while mines in which the base metals predominated reported a much higher average production, valued at over $100,000.

The average production per custom mill represented its earnings for custom work. The operations of ordinary stamp mills were quite small, averaging $1,385 per mill. Where stamp mills were equipped with concentrating plants the operations were conducted on a somewhat larger scale, averaging $8,488 per mill. It must be borne in mind that these averages are not comparable with those for stamp mills connected with mines, since the value of the ore is not included in the former, as the custom mills bought no ore.

TABLE 54.—MINES AND MILLS, WITH AMALGAMATION AND CONCENTRATION PLANTS: 1902.

	AMALGAMATION ONLY.			CONCENTRATION ONLY.		AMALGAMATION AND CONCENTRATION.		
	Mines and mills reported jointly.	Mines and mills reported separately.	Custom mills.	Mines and mills reported jointly.	Mines and mills reported separately.	Mines and mills reported jointly.	Mines and mills reported separately.	Custom mills.
Number of operators	125	82	19	32	36	104	106	22
Salaries:								
Total	$228,587	$153,526	$3,277	$227,654	$495,908	$440,159	$450,301	$40,764
Mine	...	$126,417	...	...	$395,571	...	$327,908	...
Mill	...	$27,109	$3,277	...	$100,337	...	$122,393	$40,764
Wages:								
Total	$1,378,433	$678,208	$5,774	$1,905,620	$3,240,350	$2,958,200	$2,450,680	$69,805
Mine	...	$546,796	...	...	$2,822,901	...	$1,896,357	...
Mill	...	$131,412	$5,774	...	$417,449	...	$554,323	$69,805
Contract work:								
Total	$21,151	$24,509	...	$3,039	$39,221	$52,933	$78,167	...
Mine	$21,151	$24,509	...	$3,039	$39,221	$52,933	$78,167	...
Work on share of product:								
Total	$30,036	...	...	...	$37,390	$16,400	...	...
Mine	$30,036	...	...	...	$37,390	$16,400	...	...
Miscellaneous expenses:								
Total	$170,823	$52,301	$2,478	$501,698	$316,320	$342,894	$391,963	$39,505
Mine	...	$48,468	...	...	$294,878	...	$307,604	...
Mill	...	$3,833	$2,478	...	$21,442	...	$84,359	$39,505
Cost of supplies and materials:								
Total	$585,546	$464,054	$6,225	$701,651	$1,331,443	$1,149,128	$1,093,392	$288,885
Mine	...	$272,122	...	...	$1,090,460	...	$769,748	...
Mill	...	$191,932	$6,225	...	$240,983	...	$323,644	$288,885
Crude ore shipped:								
Short tons	467	...	...	82,774	52,677	...	...	...
Value of bullion contents	$31,845	...	...	$2,326,899	$2,245,967	...	...	...
Value at works	$26,688	...	...	$1,711,583	$1,385,376	...	...	...
Average per ton	$68	...	...	$28	$43	...	...	...
Quantity of materials treated, tons:								
Total	322,989	248,396	10,933	441,874	1,250,186	758,351	1,269,243	179,618
Ore from mine	315,317	246,327	...	441,874	1,244,717	750,679	1,259,412	...
Custom ores	7,672	2,069	10,933	...	5,469	7,672	9,831	179,618
Value of bullion contents of ore treated:[1]								
Gold	$1,836,470	$958,599	...	$256,713	$1,642,979	$6,116,525	$6,310,596	[2]$1,100
Silver	$16,977	$408,041	...	$1,634,307	$2,540,560	...	$985,856	...
Other metals	$6,108	$34,051	...	$3,134,096	$5,040,216	...	$689,199	...
Total gross value	$1,859,555	$1,400,691	...	$5,025,116	$9,223,755	$6,116,525	$7,985,651	...
Average per ton	$6	$6	...	$11	$7	$8	$6	...
Treatment charges and freight	$12,856	$31,685	...	$1,538,870	$3,176,546	$855,142	$750,034	$126
Value at works	$1,846,699	$1,369,006	...	$3,486,246	$6,047,209	$5,261,383	$7,235,617	$974
Amount received for custom work	$30,573	$6,750	$26,314	...	$11,360	$30,573	$19,738	$186,742
Total value at works	$1,877,272	$1,375,756	$26,314	$3,486,246	$6,058,569	$5,291,956	$7,255,355	$187,716
Average per mine or mill	$15,018	$16,777	$1,385	$108,945	$168,294	$50,884	$68,438	$8,533

[1] Exclusive of custom ores.

[2] Ore from abandoned mine.

Chlorination plants.—There were in all 22 chlorination plants, of which 4 were combined with cyaniding plants and are included with the latter in a subsequent table. Of the remaining 18 only 7 treated their ores exclusively by chlorination; in all others the ore was first treated by amalgamation and the tailings were then treated by chlorination. In 10 mills the chlorination process was preceded by concentration.

The following table is a summary of all mines and mills with chlorination plants:

TABLE 55.—MINES AND MILLS, WITH CHLORINATION PLANTS: 1902.

	Mine and mill reported jointly.	Mine and mill reported separately.	Custom mills.
Number of operators	7	7	4
Salaries:			
Total	$107,743	$185,920	$88,605
Mine	...	$153,903	...
Mill	...	$32,017	$88,605
Wages:			
Total	$958,391	$1,725,411	$344,760
Mine	...	$1,509,213	...
Mill	...	$216,198	$344,760
Contract work:			
Total	$1,455	...	...
Mine	$1,455	...	...
Miscellaneous expenses:			
Total	$115,154	$258,642	$204,298
Mine	$115,154	$227,211	...
Mill	...	$31,431	$204,298
Supplies and materials:			
Total	$446,135	$841,216	$431,784
Mine	...	$527,178	...
Mill	...	$314,038	$431,784
Cost of purchased ores	...	$6,984	$5,660,288
Crude ore shipped:			
Tons	100,356	...	...
Value of bullion contents, total, gross	$2,515,532	...	...
Average per ton	$25	...	...
Value at mine	$1,599,614	...	...
Quantity of materials treated:			
Total, tons	98,691	399,847	368,027
Ore from mine	98,691	399,376	...
Purchased ores	...	147	368,027
Custom ores	...	324	...
Bullion contents of ores mined and treated:			
Gold—			
Ounces	14,228	57,756	363,778
Value	$293,743	$1,182,639	$7,519,299
Silver—			
Ounces	95,056	1,615,498	...
Value	$47,538	$817,507	...
Total value	$341,281	$2,000,146	$7,519,299
Average per ton	$3	$5	$20
Purchased ores:			
Value of bullion contents	...	$9,131	...
Average per ton	...	$62	...
Total gross value of product	$341,281	$2,009,277	$7,519,299
Charges for treatment and freight	$1,984	$66,750	$18,290
Value at works	$339,297	$1,942,527	$7,501,009
Amount received from custom work	[1]$254,797	$3,482	...
Total value at works	$594,094	$1,946,009	$7,501,009
Average per mine or mill	$813,387	$278,001	$1,875,252

[1] Includes $254,747, amount earned for treating 68,000 tons of ore which are included in ore sold, as treatment charges could not be segregated.

Cyaniding plants.—An exhaustive treatment of the cyaniding process will be found in a special chapter following this report. Table 56 is a summary for cyaniding mills of all descriptions, including those running on old dumps and tailings. The first five columns of the table relate to cyaniding plants connected with mines and the last column to custom mills. The former are classified according to methods of treatment, under the following heads: (1) cyanide only, (2) cyanide with crushing, (3) cyanide with amalgamation, (4) cyanide with chlorination, and (5) miscellaneous. The last column includes all mills whose expenses were not separately reported, as well as those combined with smelters, for which separate reports were furnished. The number of custom mills was too small to permit of the same classification without disclosing the identity of some individual plants.

Table 56 contains an item of $908,156, representing the value of ore shipped to other works; one portion of this amount, viz, $495,403, represents the value of ore treated at other works owned by the same operators; the quantity of this ore was not separately reported, and is therefore included in the total quantity. In computing the average value per ton it was therefore necessary to add this value in the total value of bullion contents mined and treated; the amount thus added being about 3 per cent of the true value, the error in the average can not exceed 15 cents per ton, which is immaterial, cents being disregarded in the averages.

TABLE 56.—MINES AND MILLS, WITH CYANIDING PLANTS: 1902.

	Cyanide only.	Cyanide with crushing.	Cyanide with amalgamation.	Cyanide with chlorination.	Miscellaneous.	Custom mills.
Number of operators	7	10	9	3	54	26
Salaries:						
Total	$51,907	$69,708	$95,074	$29,910	$143,236	$13,377
Mine	$44,607	$62,403	$74,255	$26,310		
Mill	$7,300	$7,305	$20,819	$3,600		$13,377
Wages:						
Total	$684,932	$505,397	$2,340,261	$521,412	$3,405,452	$215,694
Mine	$453,138	$396,544	$2,057,356	$438,185		
Mill	$231,794	$108,853	$282,905	$83,227		$215,694
Contract work:						
Total			$4,250		$21,395	
Mine			$4,250		$21,395	
Miscellaneous expenses:						
Total	$30,284	$40,947	$115,119	$58,101	$405,027	$23,066
Mine	$28,784	$34,215	$78,972	$45,692	$405,027	
Mill	$1,500	$6,732	$36,147	$12,409		$23,066
Supplies and materials:						
Total	$560,297	$283,758	$1,583,271	$200,168	$1,343,997	$121,121
Mine	$302,066	$150,860	$964,109	$146,921	$1,343,997	
Mill	$258,231	$132,898	$619,162	$53,247		$121,121
Cost of purchased ores		$900			$2,003	$702,274
Crude ore shipped to other works, value at mine	$76,487		$13,886		$817,783	
Ore treated, short tons:						
Total	392,209	153,977	1,296,345	308,357	997,744	145,730
Ore from mine	371,809	152,684	1,296,245	308,357	901,529	
Purchased ores		300			275	40,469
Custom ores		993	100		26	21,886
Old tailings	20,400				95,914	83,375
Bullion contents of ores mined and treated:						
Gold—						
Ounces	73,206	44,448	221,700	41,643	345,076	49,077
Value	$1,510,026	$918,825	$4,575,854	$860,748	$7,086,087	$1,020,728
Silver—						
Ounces	27,779	70,832	65,801	3,249	1,270,021	304,364
Value	$14,319	$36,268	$31,424	$1,690	$624,759	$163,418
Other metals—						
Value		$1,670			$13,017	$5,097
Total gross value	$1,524,345	$956,763	$4,607,278	$862,438	$7,723,863	$1,189,243
Average per ton	$4	$6	$4	$3	$8	$8
Charges for treatment and freight	$9,775	$12,084	$20,512	$5,942	$402,748	$11,239
Value at works	$1,514,570	$944,679	$4,586,766	$856,496	$7,321,115	$1,178,004
Amount received for custom work		$817	$500		$52	$79,355
Total value at works	$1,514,570	$945,496	$4,587,266	$856,496	$7,321,167	$1,257,359
Average per mine or mill	$216,367	$94,550	$509,696	$285,499	$135,577	$48,360

Cyaniding plants were mostly connected with mines; very little cyaniding work was done by custom plants. The total quantity treated at the latter was only 145,730 tons, most of which was old mine and mill dumps, whereas the total quantity cyanided at plants connected with mines was 546,286 tons, not including ore treated at mines where cyaniding was combined with other processes.

The average grade of ore treated by cyaniding at the mine was worth $5 per ton; the average grade of ore treated at custom mills was higher, somewhat over $8, which is quite natural, as the ore had to bear the additional expense of transportation. The value of the ore treated at the mine where cyaniding was the only process, or combined with amalgamation, averaged $4 per ton; where it was combined with chlorination it was found possible to treat ore worth on the average about $3 per ton. In some cases the ore was sorted, ores of a higher grade or rich in silver being shipped, while low-grade ores were treated at the cyaniding plants. The following statement shows the bullion contents of ore sold in crude state:

Bullion contents of ore sold crude: 1902.

Tons sold	60,273
Bullion contents:	
Gold—	
Ounces	29,757
Value	$560,316
Silver—	
Ounces	177,707
Value	$87,787
Copper—	
Pounds	40,000
Value	$4,000
Total gross value	$652,103
Average per ton	$11
Value at mine	$412,753

Reworking old dumps and tailings.—The development of transportation facilities and the introduction of improved processes of treatment have made it profitable to rework low-grade ores which in former years were left on the dump. The quantity of such ore treated is seldom figured as a separate item in mine accounts, and was reported to the Bureau of the Census in only a few cases. Still there were 27 custom mills operating principally on old dumps and tailings. A summary of the same is presented in the table below. Of these, 16 were cyaniding, 4 amalgamating, and 7 concentrating plants. At the last named the ore was merely concentrated and then shipped to other works for treatment. The plants were not large, employing on an average about one person on a salary and about four wage-earners. The ore and tailings treated by cyaniding averaged a little over $3 per ton.

TABLE 57.—*Summary of mills operating principally on old dumps and tailings: 1902.*

	Total.	Cyaniding mills.	All others.
Number of mills	27	16	11
Salaried officials, clerks, etc.:			
Number	33	21	12
Salaries	$41,867	$33,897	$7,970
Wage-earners:			
Average number	105	65	40
Wages	$94,139	$57,932	$36,207
Miscellaneous expenses	$20,783	$14,367	$6,416
Cost of supplies and materials	$89,061	$74,058	$15,003
Cost of purchased ore and freight	$29,783	....	$29,783
Ore treated, short tons:			
Total	137,158	80,578	56,580
Ore from the dumps	121,854	79,475	42,379
Purchased ores	4,220	80	4,140
Custom ores	11,084	1,023	10,061
Gross value of bullion contents of ore treated:[1]			
Gold	$304,176	$218,421	$85,755
Silver	$107,961	$51,745	$56,216
Other metals	$5,672	$5,097	$575
Total	$417,809	$275,263	$142,546
Average per ton	$3	$3	$3
Treatment charges and freight	$56,764	$6,130	$50,634
Value of product at mill	$361,045	$269,133	$91,912
Amount received for custom work	$28,359	$3,206	$25,153
Total value at mill	$389,404	$272,339	$117,065
Average per mill	$14,422	$17,021	$10,642

[1] Does not include custom ores.

PLACER MINES.

The following table presents comparative statistics of the production of placer mines in 1902 and 1880:

TABLE 58.—*Gold product of placer mines, by states and territories: 1902 and 1880.*

STATE OR TERRITORY.	1902	1880
	Fine ounces.	Fine ounces.
United States	535,697	580,766
Alaska	[1]276,554	288
California	182,370	415,105
Colorado	3,172	4,922
Georgia	3,280	3,234
Idaho	17,091	42,558
Montana	19,289	56,256
Nevada	1,423	2,419
New Mexico	5,722	....
North Carolina	154	227
Oregon	25,394	44,811
Washington	364	5,757
All other states and territories[2]	884	5,194

[1] Estimates of Mint officers and agents.
[2] Includes Alabama, Arizona, South Carolina, South Dakota, Tennessee, Virginia, Utah, and Washington.

The decline of placer mining in continental United States is apparent from the preceding table. While making an allowance for the incompleteness of the present Census returns for placer mines, it must be remembered that those of the Tenth Census were much more defective. About one-half of the total placer product came from Alaska. Of all other states and territories, New Mexico alone has developed some placer mining since the Tenth Census.

Methods of working.—The methods of working in use in placer mines were reported as follows: Hydraulicking, 469 mines; sluicing, 349; drifting, 112; dredging, 44; electric elevator, 1. The shares contributed by these methods to the production of placer mines are shown in the following statement:

Product of placers, classified by method used: 1902.

METHOD OF WORKING.	Value of product at mine.	Per cent.
Total	$5,327,726	100.0
Hydraulicking	1,618,169	30.4
Dredging	1,329,039	24.9
Other methods	1,242,337	23.3
Not stated	1,138,181	21.4

The following table is a summary for placer mines, classified by method of working:

TABLE 59.—*Summary for placer mines, by method of working: 1902.*

	Total.	Hydraulic.	Dredging.	All others.
Number of mines	975	469	44	462
Without hired labor	396	141	....	255
With hired labor	579	328	44	207
Number of owners working	950	385	....	565
Salaries	$324,418	$142,732	$106,747	$74,939
Wages	$1,818,758	$885,101	$321,272	$612,385
Contract work	$19,953	$10,907	$2,998	$6,048
Work on share of product	$76,749	$33,562	$3,600	$39,587
Royalties	$145,727	$45,840	$69,358	$30,529
Miscellaneous expenses, exclusive of royalties	$133,758	$59,749	$57,333	$16,676
Cost of supplies and materials	$790,986	$274,745	$345,329	$170,912
Value of product at mine	[1]$4,189,545	$1,618,169	$1,329,039	[1]$1,242,337
Average per mine	$4,295	$3,450	$30,205	$2,689
Mineral lands:				
Total acreage held	186,660	108,889	18,507	59,264
Owned, acres	167,366	99,196	14,857	53,313
Leased, acres	19,294	9,693	3,650	5,951

[1] Does not include an estimated product of $1,188,181 for a number of small mines for which no reports were received directly from operators.

Hydraulicking.—The 469 mines worked by the hydraulic method were located mainly in California, where there were 221 mines. Oregon had 137 mines, Idaho 72, Colorado and Montana 10 each, and Georgia 9. All other states combined reported only 10 mines. A summary for hydraulic mines is presented in the following table:

TABLE 60.—*Summary for hydraulic mines: 1902.*

	Total.	Productive.	Developing and producing.
Number of mines	469	[1] 397	72
Number of operators	469	397	72
Without hired labor	141	135	6
With hired labor	328	262	66
Number of owners working	385	364	21
Salaries	$142,732	$90,555	$52,177
Wages	$885,101	$647,866	$237,235
Contract work	$10,907	$2,770	$8,137
Work on share of product	$33,562	$33,562	....
Rent and royalties:			
Water rents	$27,013	$22,794	$4,219
Land, plants, and tunnels	$17,617	$17,467	$150
Other rents and royalties	$1,210	$1,210	....
Miscellaneous expenses, exclusive of rents and royalties	$59,749	$43,144	$16,605
Cost of supplies and materials	$274,745	$178,293	$96,452
Value of product at mine	$1,618,169	$1,521,562	$96,607
Average per mine	$3,450	$3,833	$1,342
Mineral lands:			
Total acreage held	108,889	80,776	28,113
Average acreage per mine	232	203	390
Owned, acres	99,196	72,348	26,848
Leased, acres	9,693	8,428	1,265

[1] Includes 1 mine for Virginia; no item shown.

About two-thirds of all mines worked by hydraulicking—viz, 307 out of 469—reported their average yield per cubic yard of gravel treated. The arithmetical mean of 260 answers for active producers was 34 cents per cubic yard, and the mean for 47 mines under development was 33 cents. The average returns are much higher than those reported at the Tenth Census, when in many mines the product was not above 10 cents per yard, and in some favorably situated workings a considerably lower rate of production was found profitable.[1] Apparently the débris legislation regulating the erection of dams for the protection of navigable waters and farming lands has added to the expense of hydraulic mining, and so permits of the working of a higher class of gravel only. This accounts for the decline of hydraulic mining, which is evidenced by the following comparative statement:

Summary for hydraulic mines: 1902 and 1870.

	1902	1870
Number of mines	469	362
Salaries	$142,732	([1])
Wages	$885,101	$906,559
Value of product at mine	$1,618,169	$2,508,531
Average per mine	$3,450	$6,930

[1] Not reported.

Placer mines combined with stamp mills.—Placer deposits are sometimes found in ancient river beds covered with a lava cap, in which case the cemented gravel is treated by crushing and amalgamation in stamp mills. Eight mines of this character were reported by the present census—7 in California and 1 in Georgia. A summary for the same follows next below:

TABLE 61.—*Summary for placer mines equipped with stamp mills: 1902.*

Number of operators	8
Salaried officials, clerks, etc.:	
Number	8
Salaries	$6,105
Wage-earners:	
Average number	67
Wages	$53,336
Contract work	$137
Work on share of product	$3,282
Miscellaneous expenses	$7,641
Cost of supplies and materials	$10,130
Value of gold at mine	$130,606
Amount received for custom work	$750
Total value of product	$131,356

Dredging.—This new method, which marks the latest technical progress in alluvial mining, deserves especial attention. The total product of gold dredged for the year 1902 was valued at $1,329,039, of which $846,421 was produced in California, $278,617 in Montana, $81,823 in Idaho, and $122,178 in Georgia and New Mexico. In 1901 the product of dredging in California was estimated at $471,762 and in 1900 at $200,000.[2]

Of the 44 mines operated by dredging, 8 were engaged mainly in developing, comparatively little gold being produced by them. These 8 mines comprised 4 in Idaho, 3 in California, and 1 in Georgia. The 36 productive mines were distributed as follows: Seventeen in California, 9 in Idaho, 5 in Montana, 3 in Georgia, and 2 in New Mexico.

There were 34 incorporated and 10 unincorporated companies. The incorporated companies were distributed by states as follows: Eighteen in California, 8 in Idaho, 5 in Montana, 2 in New Mexico, and 1 in Georgia. Of the 34 incorporated companies, 7 were reported in the development stage, and of the remaining 27 only 5 paid

[1] Tenth Census, Vol. XIII, Report on Precious Metals, page 200.

[2] Report of the Director of the Mint on the Production of the Precious Metals, 1901, page 91.

dividends in 1902, namely, 4 in California and 1 in New Mexico. The total dividends paid by these 5 companies amounted to $246,810, of which $4,760 was paid on $68,000 of preferred stock, averaging 7 per cent, and $242,050 on $1,104,000 of common stock issued, averaging 21.9 per cent. In addition to that, 1 company paid the sum of $7,680 as interest at the rate of 6 per cent on its outstanding bonds amounting to $128,000.

There was no gold dredging mine with a product of $250,000 or more. Classified by value of production reported, the 44 mines reported ranked as follows: Four with a product exceeding $100,000, and with a total of $582,598; 8 ranging between $50,000 and $100,000, with a total of $483,215; 10 ranging between $10,000 and $50,000, with a total of $199,754; 15 ranging between $1,000 and $10,000, with a total product of $59,275; 5 ranging between $500 and $1,000, and 2 producing less than $500, with a total product of $4,197. It appears from the preceding figures that four-fifths of the entire output was contributed by 12 companies, producing each between $50,000 and $250,000.

A summary for gold mines operated by dredges and the capitalization of all incorporated gold dredging companies are presented in the two tables following:

TABLE 62.—SUMMARY FOR GOLD MINES OPERATED BY DREDGES: 1902.

	Total.	Productive.	Developing and producing.	Unincorporated.	Incorporated.			
					Total.	Dividend paying.	Nondividend paying.	
							Productive.	Developing and producing.
Number of mines	44	36	8	10	34	5	22	7
Salaries	$106,747	$90,574	$16,173	$7,512	$99,235	$20,607	$62,455	$16,173
Wages:								
Total	$321,172	$287,909	$33,263	$21,853	$299,319	$82,055	$186,551	$30,713
Engineers, firemen, etc	$138,356	$125,651	$12,705	$8,495	$129,861	$39,393	$78,813	$11,655
Miners	$26,101	$15,831	$10,270	$6,994	$19,107	$9,034	$1,803	$8,770
Boys under 16	$271	$187	$84	$187	$84	.....	.....	$84
All other wage-earners	$156,444	$146,240	$10,204	$6,177	$150,267	$33,628	$106,435	$10,204
Contract work	$2,998	.....	$2,998	$2,998	.....	.....	.....	.....
Work on share of product	$3,600	$3,600	.....	$3,600	.....	.....	.....	.....
Rent and royalties:								
Electric power	$49,510	$47,913	$1,597	.....	$49,510	$19,077	$28,836	$1,597
Land, water, and other	$19,848	$19,848	.....	$1,209	$18,639	$600	$18,039	.....
Miscellaneous expenses, exclusive of royalties	$57,383	$49,980	$7,403	$699	$56,684	$9,617	$39,614	$7,403
Cost of supplies and materials	$345,329	$314,410	$30,919	$4,537	$340,792	$104,585	$206,288	$29,919
Value of product at mine	$1,329,039	$1,305,202	$23,837	$25,432	$1,303,607	$495,718	$784,152	$23,737
Average per mine	$30,205	$36,256	$2,980	$2,543	$38,341	$99,144	$35,643	$3,391

TABLE 63.—CAPITALIZATION OF INCORPORATED GOLD DREDGING COMPANIES, BY STATES AND TERRITORIES: 1902.

STATE OR TERRITORY.	Number of mines.	Total par value of stocks and bonds issued.	Capitalization.				
			Common stock.				
			Authorized.		Issued.		Dividends paid.
			Number of shares.	Par value.	Number of shares.	Par value.	
United States	34	$11,505,845	6,473,786	$11,952,800	5,405,062	$10,710,545	$242,050
Dividend paying	5	1,172,000	211,740	1,104,000	211,740	1,104,000	242,050
Nondividend paying	29	10,333,845	6,262,046	10,848,800	5,193,322	9,606,545	.....
California	18	6,275,831	3,886,998	6,704,800	3,542,849	6,207,831	197,250
Georgia	1	500,000	5,000	500,000	5,000	500,000	.....
Idaho	8	2,257,800	1,558,390	2,708,000	983,299	2,209,900	.....
Montana	5	2,252,214	1,026,200	1,820,000	871,714	1,572,814	.....
New Mexico	2	220,000	2,200	220,000	2,200	220,000	44,800

STATE OR TERRITORY.	Capitalization.										
	Preferred stock.					Bonds.					
	Authorized.		Issued.		Dividends paid.	Authorized.		Issued.		Interest paid.	
	Number of shares.	Par value.	Number of shares.	Par value.		Number.	Par value.	Number.	Par value.	Amount.	Rate per cent.
United States	208,150	$1,150,000	19,582	$633,400	$4,760	244	$184,200	219	$161,900	$7,680	6.0
Dividend paying	150	150,000	68	68,000	4,760	.....	.....	.....	.....	.....	.....
Nondividend paying	208,000	1,000,000	19,514	565,400	.....	244	184,200	219	161,900	7,680	6.0
California	150	150,000	68	68,000	4,760	.....	.....	.....	.....	.....	.....
Georgia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Idaho	200,000	200,000	14,000	14,000	.....	94	34,200	91	33,900	.....	.....
Montana	8,000	800,000	5,514	551,400	.....	150	150,000	128	128,000	7,680	6.0
New Mexico	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

The following power was used to operate the dredges: One hundred and nineteen electric motors with 4,295 horsepower owned, in addition to which 3,762 horsepower was rented from other electrical plants, making in all 8,057 horsepower; 68 steam engines with 2,385 horsepower, and 7 water wheels with 1,740 horsepower. Most of the electric power, viz, 99 motors with 3,375 horsepower, and 3,412 horsepower rented, was used in California. The power used to run dredges constituted three-fourths of the total power used in the placer mines.

The following statement shows the area of land owned and leased by gold dredging concerns; acreage was not reported for 11 mines:

Gold dredging mineral lands owned and leased, by states and territories: 1902.

	Number of mines.	ACREAGE, MINERAL LANDS.			
		Total.	Owned.	Held on lease.	Average per mine.
United States	33	18,507	14,857	3,650	561
California	18	6,596	6,396	200	366
Idaho	9	4,603	4,603		511
Montana	4	4,050	3,600	450	1,012
New Mexico	2	3,258	258	3,000	1,629

The following statement shows the distribution of mineral lands among the 33 companies reporting on the subject of land tenure:

Mineral lands, classified by area held: 1902.

	Number of mines.	ACREAGE.	
		Total.	Per cent of total.
Total	33	18,507	100.0
20 acres or less	1	20	0.1
21 to 99	3	246	1.3
100 to 999	24	8,591	46.4
1,000 and over	5	9,650	52.2

It must be understood that the land ownership shown in the preceding statements represents as yet only the possibilities of gold dredging. The area actually treated during the year 1902, in so far as reported, aggregated only 214 acres, from which gold to the amount of $1,243,364 was produced. Fifteen companies, with a total product of $185,675, failed to report the total acreage treated. The average yield per acre, for mines reporting, was $5,870. Twenty-six mines, with an aggregate output of $978,508, reported their average yield per cubic yard of gravel treated. The arithmetical mean of their average returns was $0.26 per cubic yard. In computing the mean yield the cubic volume of ground treated was not considered, as it could seldom be accurately ascertained; yet the average yield reported, being the result of numerous tests made, is thought to deserve attention.

TENDENCY TOWARD CONCENTRATION.

Gold and silver mining is no exception to the general trend of modern industry toward production on a large scale. This is illustrated by the following five tables, which present a classification of all mines and mills by value of production. Table 64 comprises all mines and all mills combined with mines, showing separately placers, deep mines without mills, and deep mines with mills. Table 65 deals with custom mills only. Table 66 presents a similar classification of all mines and mills by states and territories. Table 67 presents the same classification for gold and silver and for argentiferous lead mines, and Table 68 presents the same classification for incorporated mines, dividend paying and nondividend paying mines being shown separately. Only productive mines are dealt with in the last table; mines designated as "developing and producing"—that is, those at which expenditures were in excess of receipts—are eliminated from the comparison. In order to avoid disclosing the identity of individual concerns it has been necessary in Tables 65, 66, and 68 to combine certain groups shown separately in Tables 64 and 67.

TABLE 64.—CLASSIFICATION OF MINES BY VALUE OF PRODUCT: 1902.

	TOTAL.[1]			PLACERS.			DEEP MINES WITHOUT MILLS.			DEEP MINES WITH MILLS.		
	Number of operators.	Value of product.	Per cent.	Number of operators.	Value of product.	Per cent.	Number of operators.	Value of product.	Per cent.	Number of operators.	Value of product.	Per cent.
United States	2,937	$80,144,545	100.0	975	$5,327,726	100.0	1,275	$25,537,401	100.0	687	$49,279,418	100.0
Less than $500	765	161,531	0.2	358	77,974	1.5	332	64,690	0.2	80	18,867	0.1
$500 to $999	415	295,816	0.4	181	126,636	2.4	171	123,104	0.5	63	46,076	0.1
$1,000 to $9,999	1,134	3,976,980	5.0	359	1,118,667	21.0	505	1,827,904	7.2	270	1,030,409	2.1
$10,000 to $49,999	372	8,697,817	10.8	66	1,324,001	24.8	181	4,202,063	16.5	125	3,171,753	6.4
$50,000 to $99,999	102	7,163,460	8.9	10	643,695	12.1	33	2,325,969	9.1	59	4,193,796	8.5
$100,000 to $249,999	73	10,682,727	13.3	6	898,572	16.9	30	4,363,214	17.1	37	5,420,941	11.0
$250,000 to $499,999	45	15,517,681	19.4				16	5,717,847	22.4	29	9,799,884	19.9
$500,000 to $999,999	20	13,749,151	17.2				4	2,701,476	10.6	16	11,047,675	22.4
$1,000,000 and over	11	18,265,547	22.8				3	3,715,480	14.5	8	14,550,067	29.5
Not classified		1,633,835	2.0		1,138,181	21.3		495,654	1.9			

[1] Exclusive of custom mills.

TABLE 65.—CUSTOM MILLS, CLASSIFIED BY VALUE OF PRODUCT: 1902.

	Number of mills.	Value of product.	Per cent of total.
Total	55	$8,700,059	100.0
Less than $500	10	2,659	([1])
$500 to $999	6	3,260	([1])
$1,000 to $9,999	24	87,113	1.0
$10,000 to $49,999	7	187,982	2.2
$50,000 to $249,999	4	433,771	5.0
$250,000 and over[2]	4	7,985,274	91.8

[1] Less than one-tenth of 1 per cent. [2] Includes 3 establishments each with product over $1,000,000.

TABLE 66.—CLASSIFICATION OF MINES AND MILLS ACCORDING TO VALUE OF PRODUCT, AND THE PERCENTAGE THAT EACH GROUP IS OF THE TOTAL, BY STATES AND TERRITORIES: 1902.

STATE OR TERRITORY.	TOTAL.		LESS THAN $1,000.		$1,000 TO $9,999.		$10,000 TO $49,999.	
	Number.	Value.	Number.	Value.	Number.	Value.	Number.	Value.
United States	2,992	$82,482,052	1,196	$463,266	1,158	$4,062,016	382	$8,929,366
Arizona	74	2,764,677	23	9,233	29	132,994	13	296,347
California	1,020	15,469,609	439	164,266	400	1,296,270	119	2,631,888
Colorado	772	29,659,456	279	102,860	286	1,050,944	116	2,676,979
Idaho	258	8,177,267	122	54,673	97	810,525	20	453,294
Montana	176	4,688,536	46	16,688	70	288,988	39	965,925
Nevada	104	3,409,348	29	13,809	40	153,104	24	580,528
South Dakota	40	6,464,258	8	8,383	15	63,606	4	145,451
Utah	83	8,500,904	23	10,817	27	129,763	14	379,648
All other states and territories[1]	465	3,347,997	227	87,528	194	635,822	33	799,306

STATE OR TERRITORY.	$50,000 TO $99,999.		$100,000 AND OVER.		NOT CLASSIFIED.	PER CENT OF TOTAL.					
	Number.	Value.	Number.	Value.	Value.	Less than $1,000.	$1,000 to $9,999.	$10,000 to $49,999.	$50,000 to $99,999.	$100,000 and over.	Not classified.
United States	103	$7,221,740	153	$60,171,829	$1,638,835	0.6	4.9	10.8	8.8	72.9	2.0
Arizona	3	193,625	6	2,121,201	11,277	0.4	4.8	10.7	7.0	76.7	0.4
California	30	2,087,562	32	8,159,465	1,130,158	1.1	8.4	17.0	13.5	52.7	7.3
Colorado	27	1,994,643	64	23,824,768	9,253	0.4	3.6	9.0	6.7	80.3	([2])
Idaho	7	581,581	12	6,772,023	55,221	0.7	3.8	5.5	6.5	82.8	0.7
Montana	12	744,668	9	2,672,267	....	0.3	6.2	20.6	15.9	57.0	......
Nevada	6	449,903	5	2,066,564	145,440	0.4	4.5	17.0	13.2	60.6	4.3
South Dakota	5	365,135	8	5,886,683	....	0.1	1.0	2.2	5.6	91.1	......
Utah	6	404,591	13	7,576,085	....	0.1	1.5	4.5	4.8	89.1	......
All other states and territories[1]	7	460,082	4	1,092,773	282,486	2.6	19.0	23.9	13.5	32.6	8.4

[1] Includes Alabama, Arkansas, Georgia, Maryland, New Mexico, North Carolina, Oregon, South Carolina, Tennessee, Texas, Virginia, Washington, and Wyoming.
[2] Less than one-tenth of 1 per cent.

TABLE 67.—CLASSIFICATION OF DEEP MINES BY METALS MINED AND BY VALUE OF PRODUCT: 1902.

	TOTAL.			GOLD AND SILVER.			ARGENTIFEROUS LEAD.		
	Number of companies.	Value of product.	Per cent.	Number of companies.	Value of product.	Per cent.	Number of companies.	Value of product.	Per cent.
Total[1]	1,935	$73,961,544	100.0	1,488	$50,587,106	100.0	447	$23,374,438	100.0
Less than $500	409	82,687	0.1	322	63,746	0.1	87	18,941	0.1
$500 to $999	233	168,468	0.2	178	130,202	0.3	55	38,266	0.2
$1,000 to $9,999	759	2,773,347	3.8	602	2,181,509	4.3	157	591,838	2.5
$10,000 to $49,999	301	7,265,451	9.8	220	5,277,243	10.4	81	1,988,208	8.5
$50,000 to $99,999	90	6,355,057	8.6	66	4,583,228	9.1	24	1,771,829	7.6
$100,000 to $249,999	67	9,784,155	13.2	50	7,296,492	14.4	17	2,487,663	10.6
$250,000 to $499,999	45	15,517,681	21.0	29	9,878,109	19.5	16	5,639,572	24.1
$500,000 to $999,999	20	13,749,151	18.6	15	9,951,218	19.7	5	3,797,933	16.3
$1,000,000 and over	11	18,265,547	24.7	6	11,225,359	22.2	5	7,040,188	30.1

[1] Exclusive of custom mills and mills operated upon old dumps and tailings.

DIAGRAM I.—PRODUCTION OF GOLD FROM 1889 TO 1902 IN THE STATES AND TERRITORIES REPORTING MORE THAN 50,000 OUNCES IN 1902.

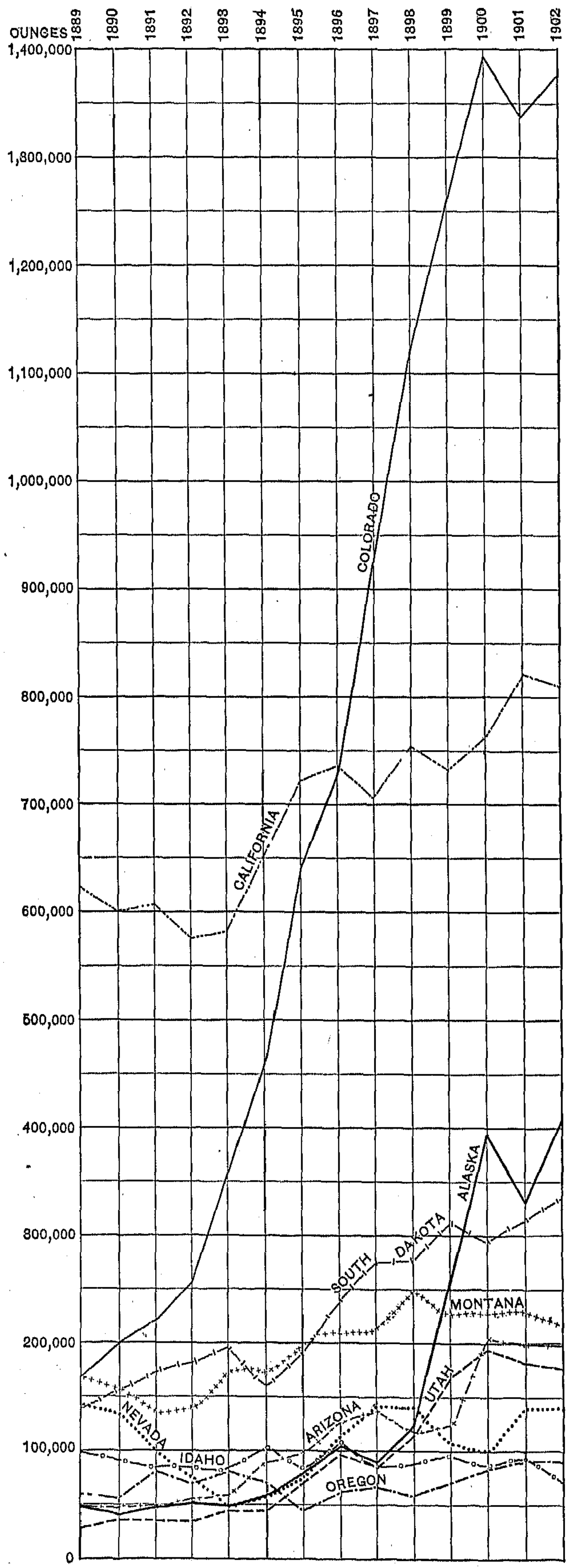


TABLE 68.—*Dividend paying and nondividend paying productive mines, deep and placer, classified by value of product: 1902.*

	DIVIDEND PAYING.			NONDIVIDEND PAYING.		
	Number of companies.	Product.	Per cent.	Number of companies.	Product.	Per cent.
All mines	121	$34,248,315	100.0	614	$31,343,626	100.0
Less than $1,000				103	45,233	0.1
$1,000 to $9,999	13	73,071	0.2	230	965,544	3.1
$10,000 to $49,999	25	686,332	2.0	152	4,019,706	12.8
$50,000 to $99,999	21	1,452,785	4.3	58	4,067,870	13.0
$100,000 to $249,999	16	2,718,437	7.9	49	7,497,403	23.9
$250,000 to $499,999	25	8,839,714	25.8	14	4,848,736	15.5
$500,000 and over	21	20,477,976	59.8	8	9,899,184	31.6
Deep mines and mills	102	33,251,898	100.0	535	29,985,701	100.0
Less than $1,000				86	35,370	0.1
$1,000 to $9,999	6	31,087	0.1	198	818,893	2.7
$10,000 to $49,999	21	610,072	1.8	130	3,482,389	11.6
$50,000 to $99,999	17	1,212,275	3.6	52	3,664,685	12.2
$100,000 to $249,999	12	2,080,774	6.3	47	7,236,494	24.2
$250,000 to $499,999	25	8,839,714	26.6	14	4,848,736	16.2
$500,000 and over	21	20,477,976	61.6	8	9,899,134	33.0
Placer mines	19	996,417	100.0	79	1,357,925	100.0
Less than $1,000				17	9,863	0.7
$1,000 to $9,999	7	41,984	4.2	32	146,651	10.8
$10,000 to $49,999	4	76,260	7.7	22	537,317	39.6
$50,000 to $249,999	8	878,173	88.1	8	664,094	48.9

PRODUCTION OF GOLD AND SILVER IN THE UNITED STATES FROM 1889 TO 1902.

The statistics of the production of the mines are collected annually by Mint officers and agents from mine operators. The statistics of the production of refineries are collected by the Bureau of the Mint. The former, as a rule, show an excess over the latter, varying from 1 per cent to 11.4 per cent for gold and from one-tenth of 1 per cent to 11.3 per cent for silver. In 1890, however, the estimate of the Director of the Mint exceeded the total gold product reported by Mint agents by 2.9 per cent. The estimated production of silver refineries exceeded the product of the mines in 1891 by five-tenths of 1 per cent, in 1893 by 13.2 per cent, and in 1896 by 8.5 per cent. The estimated production of refined silver is equal to the total silver production of domestic refineries less the silver contents of foreign ores reduced in the United States. The fluctuations in imports of silver must inevitably affect the estimate of the refined product, thus creating a disproportion between the latter and the production of the mines in the United States for the same year.

The excess appearing from year to year in the production reported by mine operators, as compared with the product of refineries, is easily accounted for by the fact that the former is largely an estimate of the assay contents of all ore mined, regardless of the quantity of ore which will eventually be left on the dump after sorting, as being of too low a grade to pay for freight and reduction; nor are the losses in smelting always considered by the mine operator in estimating the assay contents of his ore.

The following table shows the gold and silver product of mines and refineries from 1889 to 1902, compiled from the annual reports of the Director of the Mint on the production of the precious metals:

TABLE 69.—PRODUCT OF MINES AND REFINERIES: 1889 TO 1902.

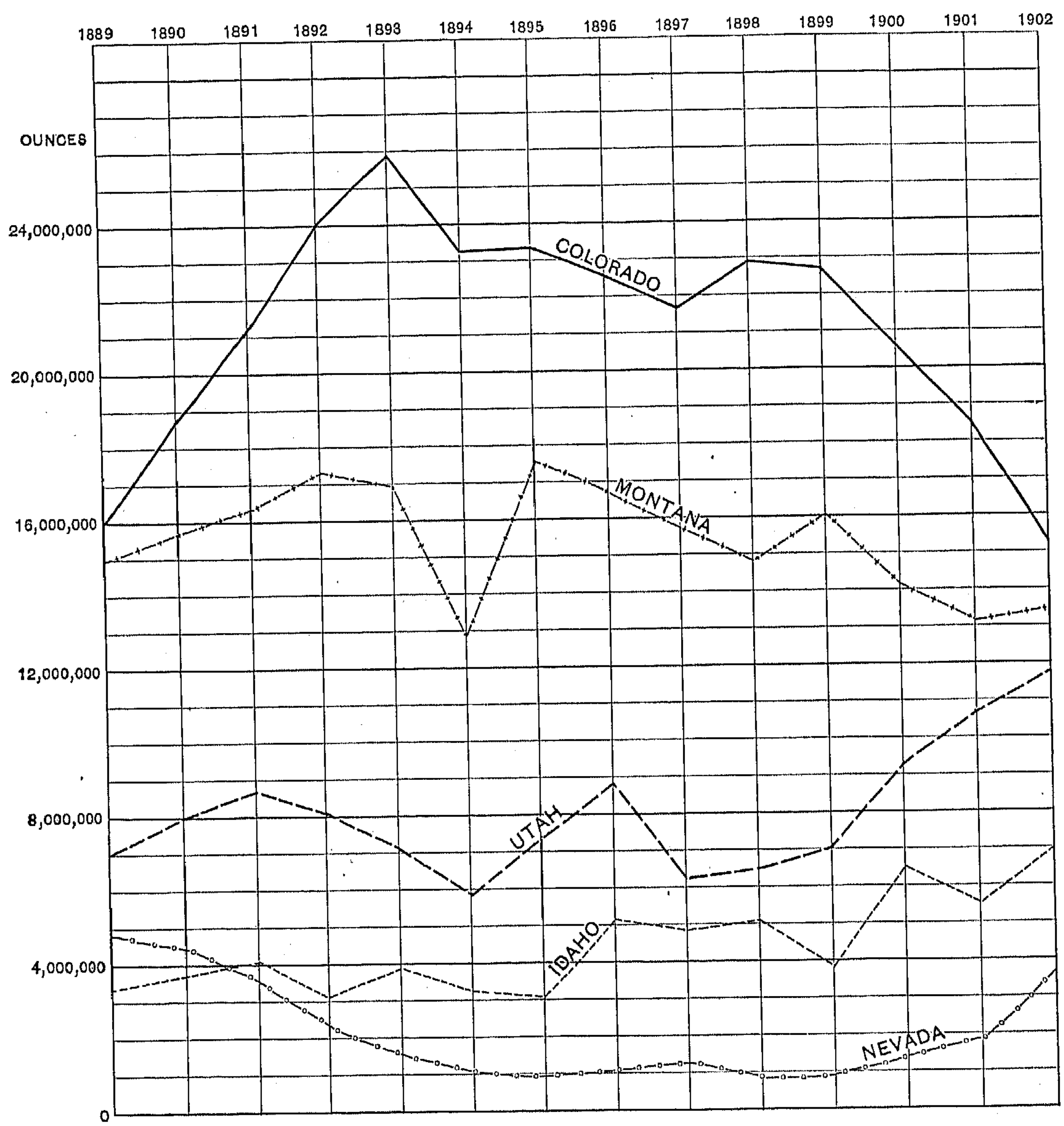
YEAR.	GOLD.				SILVER.			
	Product of mines.	Product of refineries.	Excess of mined product over refined product.		Product of mines.	Product of refineries.	Excess of mined product over refined product.	
	Fine ounces.	Fine ounces.	Fine ounces.	Per cent of mined product.	Fine ounces.	Fine ounces.	Fine ounces.	Per cent of mined product.
1902	3,918,681	3,870,000	48,681	1.1	57,836,558	55,500,000	2,336,558	4.0
1901	3,853,222	3,805,500	47,722	1.2	57,873,486	55,214,000	2,659,486	4.6
1900	3,867,644	3,829,897	37,747	1.0	60,211,386	57,647,000	2,564,386	4.3
1899	3,513,244	3,437,210	76,034	2.2	56,721,173	54,764,500	1,956,673	3.4
1898	3,184,734	3,118,398	66,336	2.1	55,486,833	54,438,000	1,048,833	1.9
1897	2,916,245	2,774,935	141,310	4.8	56,115,165	53,860,000	2,255,165	4.0
1896	2,775,141	2,568,132	207,009	7.5	54,219,609	58,834,800	[1] 4,615,131	[1] 8.5
1895	2,544,352	2,254,760	289,592	11.4	57,238,932	55,727,000	1,511,932	2.6
1894	2,110,599	1,910,813	199,786	9.5	51,028,617	49,500,000	1,528,617	3.0
1893	1,788,482	1,739,323	49,159	2.7	53,017,449	60,000,000	[1] 6,982,551	[1] 13.2
1892	1,665,626	1,597,098	68,528	4.1	58,050,975	58,004,289	46,686	0.1
1891	1,661,325	1,604,840	56,485	3.4	58,067,932	58,330,000	[1] 262,068	[1] 0.5
1890	[2] 1,544,033	1,588,877	[1] 44,844	[1] 2.9	[3] 56,320,640	54,516,800	1,804,340	3.2
1889	1,689,166	1,594,775	94,391	5.6	56,452,025	50,094,571	6,357,454	11.3

[1] Excess of refined over mined product.
[2] Exclusive of 1,935 ounces reported for "other states" in the Report of the Director of the Mint, which was evidently a duplication.
[3] Exclusive of 2,000 ounces reported for "other states" in the Report of the Director of the Mint, which was evidently a duplication.

REVIEW OF THE INDUSTRY BY STATES.

The development of the production of gold and silver in the several states and territories from 1889 to 1902 is illustrated by Diagrams I, II, III, and IV. Diagram I, based upon the estimates of the Director of the Mint, shows the growth of the gold production in the principal states and territories and the rank of each as a gold producer; the wide variance between the Mint estimates of the gold output by states and territories and the corresponding Census returns precludes the use of the latter for comparative purposes. The fluctuations of the silver production in the principal states during the same period are represented by Diagram II, prepared from the same source, except for the year 1902, for which Table 40 of the present report was used. Dia-

DIAGRAM II.—PRODUCTION OF SILVER FROM 1889 TO 1902 IN THE STATES REPORTING MORE THAN 2,500,000 OUNCES IN 1902.



grams III and IV, prepared from the same source as Diagram II, show the share contributed by each state and territory to the total production of gold and silver from year to year.

Colorado held in 1902 the first rank among the states and territories as a producer of both gold and silver. The Colorado ores contributed more than one-third of the gold and more than one-fourth of the silver contents of all ores mined in the United States. The second place among the gold producing states was held by California, which contributed over one-fifth of the gold product of the United States. Next after California came Alaska, with one-ninth of the total gold product and with more than one-half of the placer gold produced in the United States. South Dakota, Montana, Utah, Arizona, Oregon, Nevada, and Idaho followed in successive order. All other states and territories each produced less than $1,000,000 in gold.

The second rank as a silver producing state was held by Montana, which furnished nearly one-fourth of the silver contents of all ores. Nearly three-fourths of the silver was derived as a by-product of the smelting of copper ores, viz, 9,675,613 fine ounces out of a total of 13,441,950 ounces. Utah followed closely, with over one-fifth of the total output of silver. Idaho and Nevada came next. All other states and territories each produced less than $1,000,000 in silver.

Silver, as previously stated, was mostly recovered from argentiferous lead ores, where lead formed a valuable portion of the product. The first rank as a producer of argentiferous lead ores was held by Idaho. The combined silver and lead contents of all ores mined in that state were valued at $10,291,494. Utah followed next, with a total value of $8,261,095, and Colorado held the third rank, with $7,296,925. The production of argentiferous lead ores in other states was insignificant. The Colorado ores were the richest in silver, only one-fourth of the value of their bullion contents representing lead. The value of the bullion contents of Utah argentiferous lead ores was nearly two-thirds in silver and a little over one-third in lead. In Idaho, on the contrary, the ores were poor in silver, more than two-thirds of the value of their metallic contents being lead and less than one-third silver.

Taking the lead values alone, Idaho contributed $7,122,838; Utah, $2,873,740; Colorado, $1,827,993; and all other states $486,671. These values do not correspond to the quantities of lead, inasmuch as the price realized in Idaho averaged 3.4 cents per pound of fine lead contents, whereas in Utah it averaged 2.7 cents and in Colorado 2.25 cents per pound. The lead contents of Idaho ores were more than one-half of the total for all argentiferous lead ores mined in the United States. Utah contributed a little over one-fourth and Colorado about one-fifth.

A shifting of the relative positions held by the several states and territories as gold producers has taken place since the Eleventh Census. In 1889 California held the first rank; its product, as estimated by the Director of the Mint, was nearly four times as large as that of Colorado. While its production shows a small increase from year to year, yet it did not keep pace with the rapidly increasing production of Colorado, which in 1897 took the first rank and has retained it since. Alaska, which in 1889 was among the minor producers, in 1902 reached the third place, next to California.

No change has taken place in the relative positions of the three principal silver producing states, viz, Colorado, Montana, and Utah. But while the silver production of Colorado and Montana, after a period of increase up to 1895, shows a considerable decline, the silver production of Utah has substantially increased since 1889. Nevada and Idaho, which in 1889 occupied respectively the fourth and the fifth rank, have changed places, Idaho having kept up a steady increase. From 1889 to 1899 the silver production of Nevada sank into insignificance. Since 1900, however, there has been an increase, and in 1902 the silver production of Nevada was almost as great as in 1889. The variance previously referred to between the Census returns and Mint estimates for Arizona, Nevada, and Idaho accounts for the apparent decrease in 1902 of the gold production of Arizona and Nevada and for the increase of the silver production of Idaho.

It is interesting to note the relative places of the two precious metals in the principal gold and silver producing states in 1902. In Colorado a very notable change has taken place since the Eleventh Census. In 1889 the value of gold amounted to $3,883,859, and the coining value of silver to $23,757,751, which was equivalent—at the commercial rate of 93.5 cents per fine ounce[1]—to $17,500,000 in round numbers. In 1902 the value of the gold contents of Colorado ores was $26,414,800, while the commercial value of their silver contents was $7,740,227, which corresponded to a coining value of $19,617,392. Thus while the decrease of the commercial value of the silver product was nearly $10,000,000, the loss was made up by the increase in the value of the gold product, and there was a surplus of about $13,000,000 in the aggregate commercial value of both metals. The increase in the value of the gold and silver contents of the Colorado ores since 1889 amounted to 60 per cent.

In California and South Dakota the production of silver was insignificant, while in Montana and Utah the silver contents of the ores largely exceeded in value their gold contents.

Alaska.—The census of mines and quarries in 1902 did not extend to Alaska. Still, correspondence with the mining companies operating in the territory has brought replies covering all essential inquiries relating to deep mining for precious metals in the territory. There were in operation during the year 1902, 7 deep

[1]Report of the Director of the Mint on the Production of the Precious Metals, 1902, page 312.

gold and silver mines, all equipped with mills for the treatment of ores. A summary of these mines is presented in the following table:

TABLE 70.—*Summary of deep mines in Alaska: 1902.*

	Total.	Mines.	Mills.
Number of mines and mills	7	7	7
Number of operators	6	6	6
Number of incorporated companies	6	6	....
Capital stock:			
Authorized, common—			
Number of shares	1,000,000	1,000,000	....
Par value	$27,200,000	$27,200,000	....
Issued, common—			
Number of shares	878,710	878,710	....
Par value	$26,919,510	$26,919,510	....
Dividends paid	$375,000	$375,000	....
Salaries	$80,459	$73,321	$7,138
General officers	$10,687	$10,687	....
Superintendents, etc	$58,016	$50,878	$7,138
Clerks	$10,130	$10,130	....
Foremen	$1,626	$1,626	....
Wages	$821,541	$718,736	$102,805
Engineers	$113,746	$99,709	$14,037
Miners	$336,034	$336,034	....
All other wage-earners	$371,761	$282,993	$88,768
Miscellaneous expenses	$48,169	$43,548	$4,621
Contract work	$5,656	$5,656	....
Cost of supplies and materials	$700,669	$543,220	$157,449
Construction account	$105,599	$105,599	....
Total value of product at mine	[1] $2,486,183	....	$2,419,444
Tons mined	1,333,288	1,333,288	....
Tons milled	1,329,988	....	1,329,988
Tons of concentrates shipped	25,856	....	25,856
Aggregate gross value	$2,615,783	....	$2,615,783
Average per ton of ore treated	$1.97	....	$1.97
Gross value of ore milled	$1,366,734	....	$1,366,734
Refining charges	$3,272	....	$3,272
Freight and insurance	$9,555	....	$9,555
Value at mine	$1,353,907	....	$1,353,907
Gross value of concentrates shipped	$1,249,049	....	$1,249,049
Charges for treatment	$126,525	....	$126,525
Freight	$44,427	....	$44,427
Haulage	$12,560	....	$12,560
Value at mine	$1,065,537	....	$1,065,537
Income from other sources	[2] $66,739	....	....
Total contents of ore treated:			
Gold—			
Ounces	126,327	....	126,327
Value	$2,609,143	....	$2,609,143
Silver—			
Ounces	7,828	....	7,828
Value	$3,638	....	$3,638
Lead—			
Pounds	96,580	....	96,580
Value	$3,002	....	$3,002
Bullion produced:			
Gold—			
Ounces	66,154	....	66,154
Value	$1,366,306	....	$1,366,306
Silver—			
Ounces	926	....	926
Value	$428	....	$428
Concentrates, bullion contents:			
Gold—			
Ounces	60,173	....	60,173
Value	$1,242,837	....	$1,242,837
Silver—			
Ounces	6,902	....	6,902
Value	$3,210	....	$3,210
Lead—			
Pounds	96,580	....	96,580
Value	$3,002	....	$3,002

[1] Includes $66,739 income from other sources.
[2] Income that can not be credited to mines or mills.

The bullion contents of gold and silver ore produced in 1902, as shown in the preceding table, were as follows: Gold, 126, 327 fine ounces, valued at $2,609,143; silver, 7,828 ounces, valued at $3,638.

In addition to these quantities three copper mining companies reported to the Bureau of the Census the assay contents of their copper ore as follows: Gold, 370 fine ounces, worth $7,016; silver, 3,140 fine ounces, worth $1,567.

This makes in all 126,697 fine ounces of gold, valued at $2,616,159, and 10,968 ounces of silver, valued at $5,205. The Mint agents estimated the product of Alaska deep mines as follows: Gold, 124,156 fine ounces; silver, 89,388 fine ounces.

The Census returns from producers exceed the Mint agents' estimate of the gold product by 2,541 ounces. The Mint agents' estimate of the silver product of deep mines is many times in excess of the Census returns from producers. Inasmuch as no allowance is made in the silver estimate for the silver contents of placer bullion, which on a gold product of about $2,500,000 must be considerable, it is apparent that the estimate is meant to comprise the silver contents both of ore and of placer bullion. The product of placer mines is estimated by the Mint agents at 276,554 fine ounces.

The total product of Alaska in 1902, as estimated by the Director of the Mint, is somewhat above that of the Mint agents, viz: Gold, 403,730 fine ounces, worth $8,345,800; silver, 92,000 fine ounces, worth $118,950. This estimate is accepted by the Bureau of the Census.

The growth of the gold production of Alaska since 1890 is shown in the following table, compiled from the annual reports of the Director of the Mint on the production of the precious metals. The statistics for some years include silver; the percentage of silver in Alaska ores is, however, so insignificant that the error may be disregarded.

TABLE 71.—*Production of gold in Alaska: 1890 to 1902.*

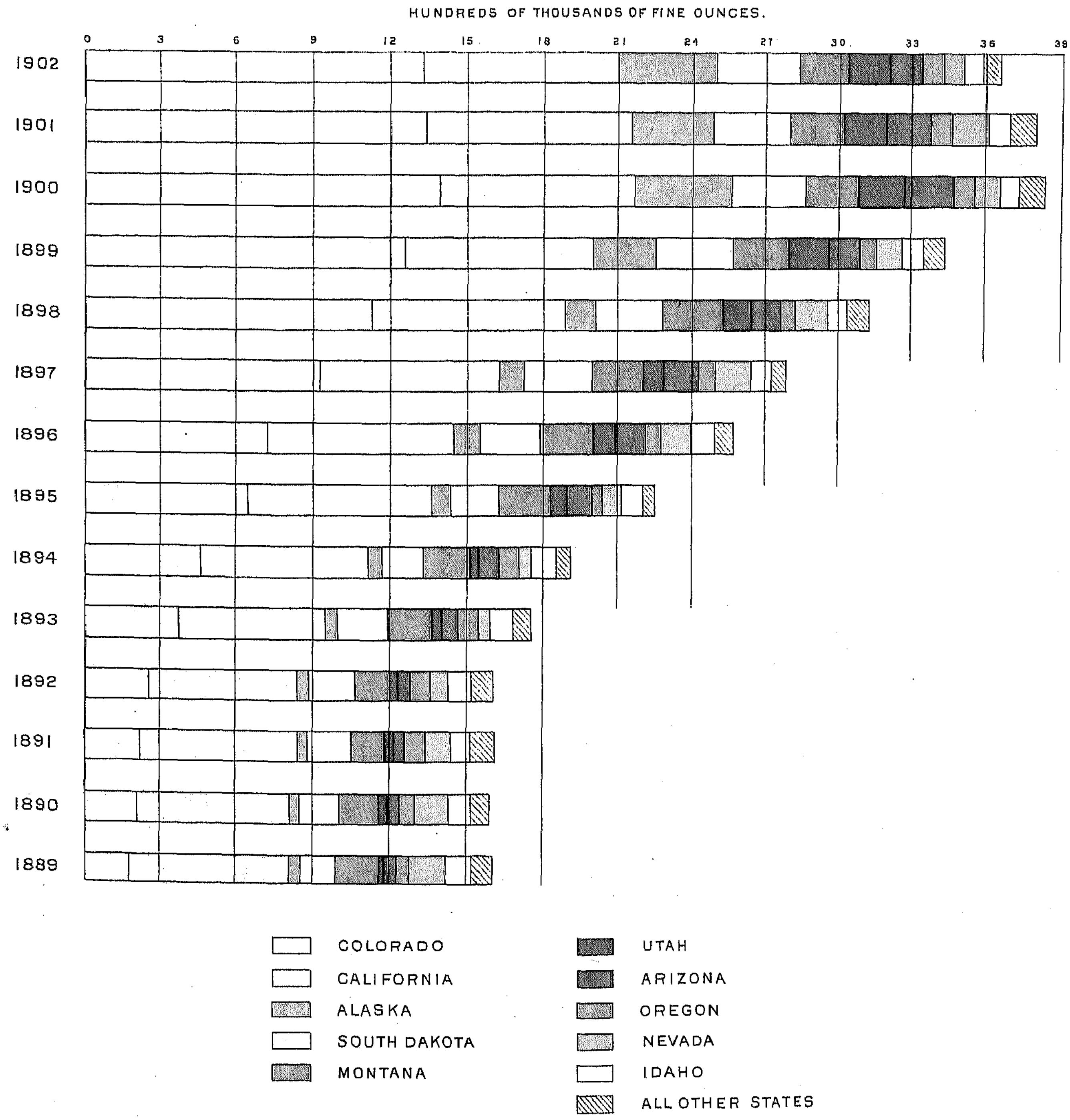
[Compiled from Report of Director of the Mint.]

Year.	Total value.	Quartz.	Placer.
Total	$44,610,478	$18,747,306	$25,863,167
1890	762,429	687,429	75,000
1891	1,020,045	880,045	140,000
1892	1,080,446	845,046	235,400
1893	1,038,824	779,782	259,042
1894	1,282,623	759,350	523,273
1895	2,328,419	1,311,337	1,017,082
1896	2,861,307	1,370,862	1,490,445
1897	2,439,582	1,760,793	678,789
1898	2,517,121	1,010,356	1,506,765
1899	5,831,355	2,704,176	3,127,179
1900	8,166,187	2,089,818	6,076,369
1901	6,998,726	1,981,775	5,016,951
1902	8,283,409	2,566,537	5,716,872

The preceding table shows that the growth of Alaska as a gold mining district is chiefly due to the development of placer mining, which has, since 1898, outrun the production of deep mines, whereas previous to 1898 the placer production amounted to 34.5 per cent of the total output. The share of placer mines in the total production for 1898 to 1902 amounted to 67.4 per cent.

The history of deep mining in Alaska is practically a record of the work of three companies, the Alaska Treadwell, the Alaska-Mexican, and the Alaska United gold mining companies, which are controlled by the same interests and operated under a joint management. The annual statements of these companies to their stockholders set forth in minutest detail the accounts of their operations and furnish an instructive example of the successful mining of low-grade ores. By courtesy of

DIAGRAM III.—PRODUCTION OF GOLD: 1889 TO 1902.



President William Alvord, the Bureau of the Census has been given the privilege of using these statements in the present report.

The Alaska Treadwell Gold Mining Company is the oldest of the three companies. It is incorporated with a capital stock of $5,000,000, divided into 200,000 shares of $25 each, all issued. The mine has been in active operation since August, 1885, and yielded during that time $13,484,311 in gold, at an average of $2.57 per ton; the operating costs for the same period averaged $1.29 per ton. The operating profits aggregated $6,742,149.58, and have thus more than repaid the entire capital stock at its par value. The yield per ton has been declining, but the operating costs have also been materially reduced, while the tonnage crushed has more than trebled since 1890. As a result, the company's operating profits for the year 1902 were considerably larger than in years past when the yield per ton was higher. The progress in the methods of treating the ore is evidenced by the fact that while the yield in free gold has been steadily decreasing, the value saved by reworking the ore after the free gold is extracted shows a marked increase both in amount and in proportion to the total recovery. The results accomplished by the company are shown in the following statement:

Bullion shipments from Paris or Treadwell mine: 1890 to 1902.

[From beginning of work to May, 1903.]

DATE.	Tons crushed.	YIELD. Total.	YIELD. Free gold.	YIELD. Concentrates (sulphurets).	Operating profits.	Yield per ton.	Operating costs per ton.
Total	4,624,289	$11,144,912.24	$7,069,917.85	$4,074,994.39	$5,667,149.58	$2.41	$1.18
1890–91, June to May	220,686	769,765.80	531,185.77	238,580.03	418,209.90	3.49	1.59
1891–92, June to May	239,683	707,017.37	508,894.81	198,122.56	361,980.16	2.95	1.44
1892–93, June to May	237,235	694,658.74	504,785.46	189,873.28	385,618.79	2.94	1.30
1893–94, June to May	220,043	705,948.03	518,194.34	187,753.69	429,948.86	3.20	1.25
1894–95, June to May	241,278	626,327.06	411,070.66	215,256.40	309,584.56	2.60	1.31
1895–96, June to May	263,670	782,829.67	528,958.80	253,870.87	497,342.22	2.97	1.08
1896–97, June to May	242,027	676,064.88	452,407.30	223,657.58	376,450.90	2.79	1.24
1897–98, June to May	254,329	586,857.42	389,740.00	197,117.42	313,075.60	2.31	1.20
1898–99, June to May	250,408	677,655.13	441,282.25	236,372.88	386,792.34	2.71	1.28
1899–1900, June to May	557,960	1,153,367.60	773,165.69	380,201.91	669,301.20	2.07	0.86
1900–1901, June to May	457,802	860,736.58	559,126.37	301,610.21	377,417.34	1.88	1.05
1901–2, June to May	682,898	1,304,720.54	665,591.27	639,129.27	481,633.94	1.91	1.20
1902–3, June to May	756,325	1,598,963.42	785,515.13	813,448.29	659,849.77	2.11	1.24

The total assay value of the ore treated at the company's two mills during the fiscal year ending on May 15, 1903, was $1,697,507, and the total net value recovered in the mills was $1,613,991—i. e., about 95 per cent of the assay contents. The total yield per ton for the same year was $2.11, of which $1.04 was free gold and $1.07 was saved in sulphurets. The average value of sulphurets per ton after concentration was $52.58. The net profit for the year was $692,208.94, out of which $375,000 were paid in dividends during the year. The amount written off for depreciation was $448,493. During the year there was an average of 33 machine drills at work in the mine. The average number of drills used in mining the ore (stoping) was 14.5. The others were used in development and other kinds of work. The average work of one machine per shift of ten hours was 38 tons.

The Alaska-Mexican Gold Mining Company is incorporated with a capital stock of $1,000,000, divided into 200,000 shares of $5 each, of which $900,000 are outstanding. The mine has been in active operation since 1894, and has yielded during that time $2,816,279 in gold, at an average of $2.18 per ton. The operating cost averaged for the same period $1.73 per ton. The operating profits aggregated $587,912, out of which $465,381 were paid in dividends. What has been said above of the Alaska Treadwell Mining Company in regard to the grade of ore and the values recovered in sulphurets is likewise true of the Alaska-Mexican mine, as shown by the following statement:

Bullion shipments from Alaska-Mexican mine: 1894 to 1902.

[From beginning of operations to December 15, 1902.]

YEAR.	Tons crushed.	YIELD. Total.	YIELD. Free gold (including base bars).	YIELD. Concentrates (sulphurets).	Operating profits.[1]	Total yield per ton.	Operating costs per ton.	Operating profits per ton.
Total	1,298,662	$2,816,278.83	$1,859,261.20	$957,017.63	$587,911.92	$2.18	$1.73	$0.45
1894	73,141	204,042.46	154,643.33	49,399.13	60,215.60	2.79	1.97	0.82
1895	79,439	226,258.07	155,637.54	70,620.53	71,391.78	2.85	1.95	0.90
1896	101,702	245,861.98	169,532.32	76,329.66	61,650.48	2.42	1.81	0.61
1897	158,005	335,628.67	226,321.71	109,306.96	87,101.46	2.12	1.57	0.55
1898	162,457	375,882.36	257,484.67	118,397.69	100,663.07	2.31	1.69	0.62
1899	166,054	347,414.97	231,841.23	115,573.74	62,338.42	2.09	1.73	0.38
1900	166,449	315,005.45	233,105.08	81,900.37	33,821.02	1.89	1.69	0.20
1901	178,960	339,452.31	213,923.07	125,529.24	24,709.63	1.90	1.76	0.14
1902	207,455	426,732.56	216,772.25	209,960.31	86,025.51	2.06	1.64	0.41

[1] Included in the operating profits is a total of $3,573.79, distributed as follows: Profit on sale of 31,000 shares of stock in 1893, $575.95; interest received in 1898, $694.46; interest received in 1899, $1,682.76; interest received in 1900, $620.62.

The grade of ore mined in 1902 was the same as that of the Alaska Treadwell Gold Mining Company. The average value per ton was $2.06, of which $1.04 was recovered in free gold and $1.02 was saved in sulphurets. The average value of sulphurets per ton, after concentration, in 1902 was $59.51. The net profit for the year was $86,025.

The following summary is compiled from the profit and loss accounts of the Alaska Treadwell Gold Mining Company for the year ending May 31, 1903, and the Alaska-Mexican and the Alaska United gold mining companies for the calendar year 1902:

Profit and loss account of the Alaska Treadwell, Alaska-Mexican, and Alaska United gold mining companies.

	Alaska Treadwell (year ending May 31, 1903).	Alaska-Mexican (calendar year 1902).	ALASKA UNITED.	
			Ready Bullion Mine (calendar year 1902).	Seven Hundred Foot Mine (calendar year 1902).
Ore mined, tons	756,325	207,455	226,522	118,541
Ore milled, tons	756,325	207,455	226,522	118,541
Sulphuret saved, tons	15,470.79	3,528.28	4,158.80	1,271.39
EXPENSES PER TON.				
Mining	[1]$0.9022	[1]$1.0590	[1]$0.9954	$0.7608
Milling	0.1614	[2]0.2322	[3]0.3176	[4]0.1912
Sulphuret	0.1487	0.1248	0.1323	0.0804
General expense at Douglas Island	0.0068	0.0193	0.0138	0.0219
San Francisco office	0.0095	0.0112	0.0060	0.0096
London office	0.0017	0.0030	0.0012	0.0019
Paris office	0.0003	0.0005	....	....
Consulting engineers	0.0015	0.0049	0.0024	0.0089
Bullion charges	0.0096	0.0100	0.0081	0.0075
Litigation	....	....	....	0.0840
Total operating expense	1.2417	1.4649	1.4768	1.1012
Construction cost	0.0454	[5]0.1774	0.0220	0.0065
Total operating and construction cost	1.2871	1.6423	1.4988	1.1677
RECEIPTS PER TON.				
Free gold	1.0362	1.0199	0.8589	0.8113
Base bars	0.0024	0.0250	0.0113	....
Sulphurets	1.0755	1.0121	0.6049	0.5197
Total	2.1141	2.0570	1.4751	1.3310
Interest	0.0019	....	....	....
Profits from other sources	0.0863	....	....	....
Grand total	2.2023	2.0570	1.4751	1.3310
Net profit for year	0.9152	0.4147	....	0.1633
Deficit for year	....	....	0.0237	....

[1] Includes cost of development work.
[2] Includes cost of concentrating 3,792.27 tons sulphurets.
[3] Includes cost of concentrating 4,640 tons sulphurets.
[4] Includes cost of concentrating 2,188 tons sulphurets.
[5] $0.1150 per ton of reconstruction work.

The Alaska United Gold Mining Company is the youngest of the three companies. It began operations on the Ready Bullion claim in November, 1898, and on the Seven Hundred Foot claim in April of the following year. The total yield of the former from beginning of operations to December 15, 1902, aggregated $1,539,480, averaging $2.03 per ton. The operating cost averaged $1.72 per ton and the operating profits 31 cents per ton.

The Seven Hundred Foot claim produced from the beginning of operations to December 15, 1902, $665,376 in gold and base ores, averaging $1.59 per ton; the operating cost averaged $1.56 per ton, leaving a profit of 3 cents per ton. The company was capitalized at $1,000,000, divided into 200,000 shares of $5 each, of which $901,000 are outstanding. The total operating profits since organization amounted to $250,491. There was a deficit for the year on the Ready Bullion claim amounting to 2 cents per ton, but the construction account on the same mine, charged to current expenses, likewise averaged 2 cents per ton.

California.—California had more operators than any other state, viz, more than one-third of the total number reported for the United States. Eliminating from the latter total the 447 argentiferous lead mines and considering only gold and silver mines, California had about two-fifths of the total number of operators reported for the United States. This does not include small operators from whom no individual reports were received; the latter were also located chiefly in California. Of the total estimated value of the product of small mines, 70 per cent, viz, $1,130,158, was reported from California. It is therefore a fair estimate that there were in 1902 more operators of gold mines in California than in all other states and territories, Alaska not being included in the comparison.

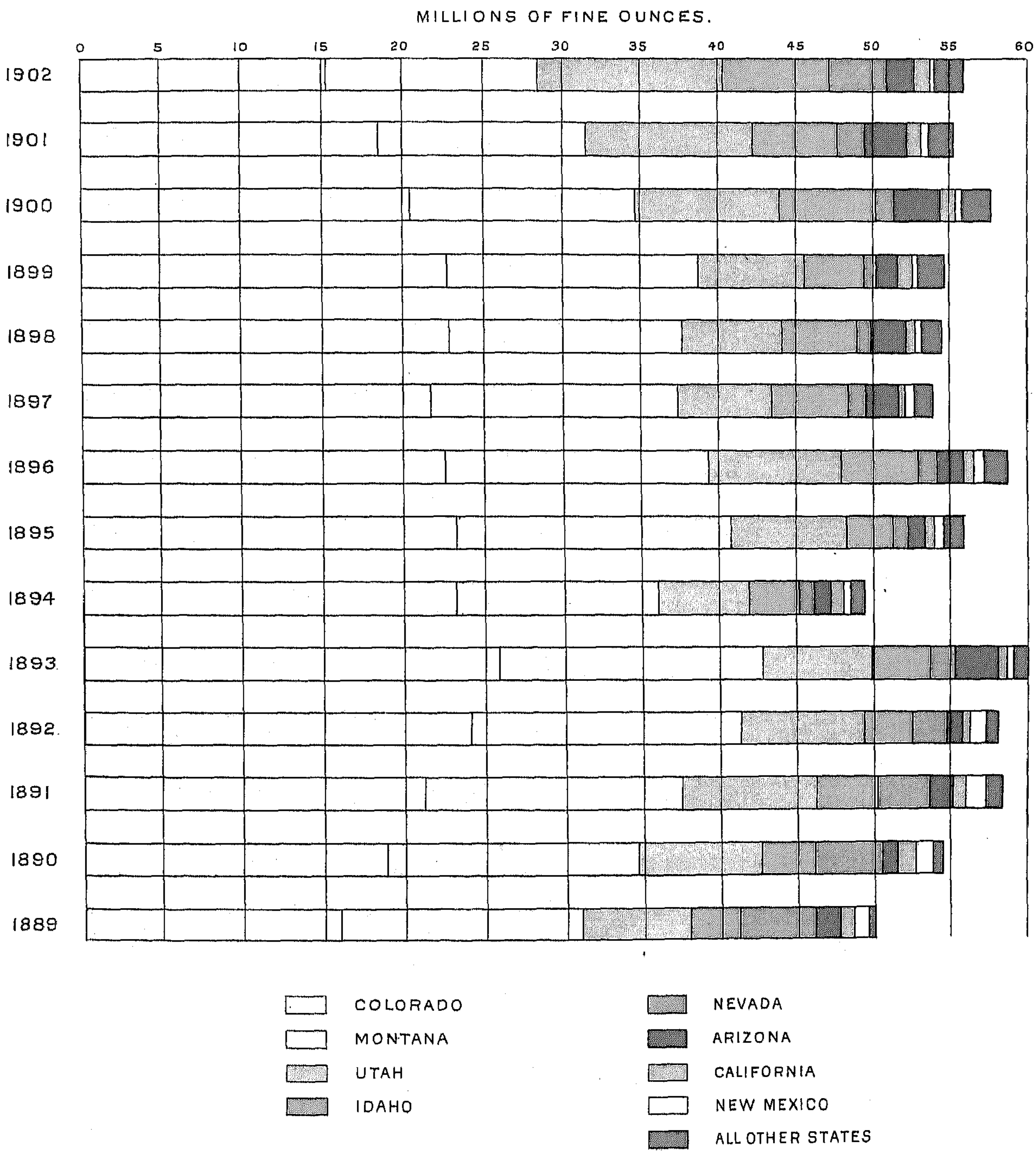
The majority of mine operators in California were interested in placer mines; measured by their output, however, the placer mines of California were of minor importance in comparison with the deep mines of the state. Small operators employing no hired labor were still very numerous in 1902 among the owners of placer mines. Reports were received from 316 mines operated without hired labor; each mine was worked on the average by two owners; the average value of product per mine was $924. Two-thirds of the product of this class of operators was obtained from placer mines. Where deep mines were worked without hired labor, only high-grade ore, averaging $25 per ton, was treated.

Most of the deep mines were equipped with mills for the treatment of their ores. Those which had no facilities for the treatment of their ores were very small, employing an average of about two men throughout the year; their annual production averaged only about $3,000 per mine. They treated only high-grade ore, averaging $24 per ton. Those mines which were provided with milling facilities were able to treat ores averaging $5 per ton; their annual production averaged $43,720 per mine.

There were among the operators 31 incorporated companies by which dividends were declared in 1902, aggregating $1,099,399, and averaging 4 per cent on the total outstanding capital stock. The ore treated by these companies was of a low grade, averaging only a little over $7 per ton. Their total production for 1902 was valued at $4,866,812, or an average of $156,994 per mine.

The tendency toward concentration of production was pronounced. Thirty-two of the operators, each with an output of $100,000 or over, produced more than one-

DIAGRAM IV.—PRODUCTION OF SILVER: 1889 TO 1902.



half (52.8 per cent) of the total product, whereas all small producers (those whose output was less than $1,000, as well as those of a shifting character who made no individual reports) contributed in all 8.3 per cent of the total output of the state.

The tables which follow present the principal statistical facts for California. Table 72 is a comparative summary for deep mines with and without mill connection; arrastras, custom mills, and mines run exclusively on old tailings are not included in the comparison. Table 73 is a summary for placer mines, exclusive of 7 mines connected with stamp mills. Table 74 is a summary for 316 mines operated by the owners without hired labor, and Table 75 is a summary for dividend paying mines.

TABLE 72.—*Deep mines, with and without mill connections in California: 1902.*

	Deep mines without mill connection.	Mines and mills reported jointly.	MINES AND MILLS REPORTED SEPARATELY.	
			Mines.	Mills.
Number of operators	151	134	112	....
Salaried officials, clerks, etc.:				
Number	39	212	266	53
Salaries	$41,207	$304,349	$420,984	$73,408
Wage-earners:				
Average number	339	2,311	3,388	446
Wages	$311,318	$2,059,728	$3,123,477	$440,081
Contract work	$4,926	$16,958	$17,552	....
Work on share of product	$25,869	$42,575	$51,790	....
Miscellaneous expenses	$22,478	$243,235	$425,225	$70,364
Cost of supplies and materials	$101,411	$746,818	$1,253,955	$351,712
Crude ore shipped, short tons	22,415	....	....	....
Ore treated, total, short tons	....	645,913	....	1,640,247
Mined and treated	....	636,394	....	1,637,978
Purchased ores	....	....	....	147
Custom ores	....	9,519	....	2,122
Value of bullion contents:				
Crude ore shipped—				
Gold	$467,671	....	....	....
Silver	$64,876	....	....	....
Other metals	$6,187	....	....	....
Total	$538,234	....	....	....
Average per ton	$24	....	....	....
Treatment charges and freight	$91,656	....	....	....
Value at mine	$446,578	....	....	....
Ore treated—				
Gold	....	$3,487,910	....	$7,449,885
Silver	....	$42,152	....	$70,152
Other metals	....	$1,000	....	$1,670
Total	....	$3,531,062	....	$7,521,707
Average per ton	....	$6	....	$5
Treatment charges and freight	....	$111,207	....	$214,937
Value at mill	....	$3,419,855	....	$7,306,770
Amount received for custom work	....	$34,642	....	$13,897
Cost of purchased ore, including freight	....	....	....	$6,934
Total value of product at mill	....	$3,454,497	....	$7,313,733
Average per mine or mill	$2,957	$25,780	....	$65,301

TABLE 73.—*Summary for placer mines in California: 1902.*

Number of mines	547
Without hired labor	243
With hired labor	304
Number of owners working	653
Salaried officials, clerks, etc.:	
Number	170
Salaries	$199,473
Wage-earners:	
Average number	1,445
Wages	$1,114,513
Contract work	$7,630
Work on share of product	$35,834
Miscellaneous expenses	$200,518
Cost of supplies and materials	$468,483
Value of product at mine	$2,825,579

TABLE 74.—*Mines operated without hired labor in California: 1902.*

Number of mines	316
Number of owners working	674
Contract work	$610
Total miscellaneous expenses	$20,716
Rent and royalties—	
Mine and mineral lands	$11,208
Water	$1,728
Other	$4,505
Other miscellaneous expenses	$3,273
Cost of supplies and materials	$24,641
Product:	
Placer—	
Value at mine	$207,584
Deep—	
Tons sold or treated	3,861
Gross value of bullion contents	$95,259
Average per ton	$25
Charges for treatment and freight	$11,003
Value at mine	$84,256
Total value of product	$291,840
Average per mine	$924

TABLE 75.—*Summary for dividend paying productive mines in California: 1902.*

Number of mines	31
Par value of stock issued	$25,538,210
Dividends	$1,099,399
Salaries	$216,038
Wages	$1,638,891
Contract work	$7,218
Miscellaneous expenses	$232,284
Cost of supplies and materials	$693,252
Ore treated, short tons—	
Ore from mine	560,003
Purchased ores	147
Custom ores	7,722
Value of bullion contents:	
Ore from mine—	
Placer—	
Gold	$809,118
Silver	$395
Total gross value	$809,513
Treatment charges, including freight	$3,157
Value at mine	$806,356
Deep—	
Gold	$4,071,974
Silver	$38,545
Lead	$2,467
Total gross value	$4,112,986
Average per ton	$7
Treatment charges, including freight	$85,515
Value at mine	$4,036,602
Purchased ore, gold value	$9,131
Cost of purchased materials, including freight	$6,934
Amount received for custom work	$30,788
Total value of product	$4,866,812
Average per mine	$156,994

Colorado.—In 1902 Colorado was the principal gold and silver producing state. Only the largest mines had their own reduction works; their number was less than one-tenth of the total number of mines in the state, while their product amounted to over two-fifths of the total for the state. The average grade of ore treated at mills connected with mines was valued at $9 per ton, whereas the ore shipped from mines without mills of their own was worth $20 per ton.

About one-half of the mines without mill connections expended more during 1902 than the value of their product. The average value of their ore was the same as in other mines of the same class, viz, $20 per ton; the treatment charges and freight averaged with them $7.16 per ton, and with others $6.42 per ton. Apparently there was no difference, either in the grade of their ore or in their location, which would place them at a disadvantage as compared with other mines. It is therefore fair to assume that the surplus expenditure was invested in development work.

The leasing system is a prominent feature in Colorado. The total amount of royalties for mine and mineral lands reported by operators whose mines were located exclusively on leased land was $379,521, and the aggregate value of their product at the mines was $2,190,840. Thus the average rate of royalties was 17.3 per cent. The average production per mine in 1902 was valued at $11,352.

This number of lessees does not comprise the class of small operators locally known as "leasers," "block lessees," etc., and designated in this report as "share workers." Two-thirds of the total number of such operators in the United States, viz, 814 out of 1,230, were reported from Colorado. The total amount realized by them, after deducting royalties, was $1,106,602, making an average of $1,359 per "lease." A concise description of the system of mining on shares was furnished by Mr. Kenneth McKenzie, vice-president and general manager of the Acacia Gold Mining Company, Cripple Creek, Teller county, Colo., in a communication dated May 19, 1903, in reply to an inquiry from the Bureau of the Census. "There are generally from 2 to 6 men interested in a lease; some of them work out for wages and divide up their wages with their partners working on the leased ground until they find ore enough to pay expenses, which very often they never do. Many of the men would be working for half wages and an interest in the lease. All properties that are operated by lessees in the Cripple Creek district are worked much the same as ours."

There were 47 incorporated companies which declared dividends in 1902. The total amount of dividends paid by them was $3,689,444, averaging 5.2 per cent on the par value of an outstanding capital stock of $70,753,173. The total value of their product was $13,801,413—i. e., nearly one-half of the total product of the gold and silver mines of the state; the average per mine was $293,647. The ore mined by them was of a high grade, averaging $20 per ton.

The tendency toward concentration was quite pronounced in Colorado. Sixty-four mines each producing $100,000 or more contributed over four-fifths (80.4 per cent) of the output of the state; 279 operators each producing less than $1,000 contributed only three-tenths of 1 per cent; and 429 with a product ranging from $1,000 to $100,000 produced less than one-fifth.

The principal statistical data for Colorado are presented in Tables 76, 77, 78, and 79. Table 76 is a comparative summary of deep mines with and without mills; productive mines, and mines where the work was chiefly development, are shown in separate columns. Table 77 is a summary of deep mines operated on leased land only. Table 78 is a comparative summary of mines worked on shares with and without hired labor. Table 79 is a summary for dividend paying companies.

TABLE 76.—*Summary for deep mines with and without mills in Colorado: 1902.*

	DEEP MINES WITHOUT MILL CONNECTION.		Mines and mills reported jointly.	MINES AND MILLS REPORTED SEPARATELY.	
	Productive.	Developing and producing.		Mines.	Mills.
Number of operators	351	312	80	34	....
Salaried officials, clerks, etc.:					
Number	441	283	192	117	50
Salaries	$641,705	$332,966	$336,736	$158,594	$72,095
Wage-earners:					
Average number	4,454	2,178	2,420	1,216	261
Wages	$4,782,276	$2,218,265	$2,620,938	$1,295,185	$292,620
Contract work	$171,062	$115,926	$39,003	$34,694	....
Work on share of product	$875,379	$194,244	$36,979	....	....
Miscellaneous expenses	$1,077,709	$276,908	$400,095	$131,356	$18,881
Cost of supplies and materials	$2,133,863	$1,111,352	$1,118,352	$441,870	$131,486
Crude ore shipped, tons.	1,058,441	146,310	87,175	....	....
Ore treated, total tons	....	....	596,068	....	490,190
Mined and treated	....	....	562,320	....	476,353
Custom ores	....	....	33,748	....	13,837
Value of bullion contents:					
Crude ore shipped—					
Gold	$15,450,566	$2,353,347	$1,859,641	....	....
Silver	$4,390,867	$473,959	$302,132	....	....
Lead	$967,489	$100,051	$211,805	....	....
Other metals	$436,648	$28,657	$202	....	....
Total	$21,245,570	$2,951,014	$2,373,780	....	....
Average per ton	$20	$20	$27	....	....
Treatment charges and freight	$6,793,420	$1,048,262	$1,059,016	....	....
Value at mine	$14,452,150	$1,902,752	$1,314,764	....	....
Ore treated—					
Gold	....	....	$4,195,086	....	$2,470,258
Silver	....	....	$1,016,078	....	$661,593
Lead	....	....	$363,570	....	$184,328
Other metals	....	....	$226,137	....	$166,715
Total	....	....	$5,800,871	....	$3,482,894
Average per ton	....	....	$10	....	$7
Treatment charges and freight	....	....	$661,888	....	$402,800
Value at mill	....	....	$5,138,983	....	$3,080,094
Amount received for custom work	....	....	[1] $360,051	....	$23,314
Total value of product	....	....	$6,820,398	....	$3,103,408
Average per mine or mill	$41,174	$3,099	$227,347	....	$91,277

[1] Includes $254,797 charged by reduction works against their own mines and credited by the latter to their reduction works.

TABLE 77.—*Summary for deep mines operated on leased land only in Colorado: 1902.*

Number of mines	193
Number of owners working	93
Salaries	$119,603
Wages	$909,788
Contract work	$33,709
Work on share of product	$9,634
Rents and royalties of mines and mineral lands	$379,521
Other miscellaneous expenses	$66,572
Cost of supplies and materials	$380,694
Value of product at mine	$2,190,840
Average per mine	$11,352
Ore sold and treated, short tons	170,057
Value of bullion contents:	
Gold	$1,895,758
Silver	$792,143
Other metals	$430,666
Total gross value	$3,118,567
Average per ton	$18
Acreage leased	4,398
Average acreage per mine	23

TABLE 78.—*Summary for mines worked on shares in Colorado: 1902.*

	Total.	Without wage labor.	With wage labor.
Number of mines	157	127	30
Number of owners working	4	4	....
Salaries	$177,243	$17,824	$159,419
Wages	$841,282	....	$841,282
Contract work	$29,860	$8,520	$21,340
Share workers:			
Number	814	321	493
Amount paid	$1,106,602	$475,055	$631,547
Miscellaneous expenses	$212,340	$36,324	$176,016
Cost of supplies and materials	$423,826	$13,430	$410,396
Ore sold and treated, short tons	204,938	49,468	155,470
Value of bullion contents:			
Gold	$2,751,716	$609,284	$2,142,432
Silver	$1,066,680	$251,271	$815,409
Other metals	$202,496	$55,052	$147,444
Total gross value	$4,020,892	$915,607	$3,105,285
Average per ton	$20	$19	$20
Value of product at mine	$2,767,879	$616,041	$2,151,838
Average per mine	$17,630	$4,851	$107,592

TABLE 79.—*Summary for dividend paying productive mines in Colorado: 1902.*

Number of mines	47
Par value of stock issued	$70,758,178
Dividends	$3,689,444
Salaries	$576,379
Wages	$4,528,646
Contract work	$133,835
Work on share of product	$272,697
Miscellaneous expenses	$726,718
Cost of supplies and materials	$2,287,080
Ore treated, short tons	930,782
Value of bullion contents:	
Gold	$14,144,404
Silver	$3,063,608
Copper	$141,201
Lead	$901,379
Other metals	$343,270
Total gross value	$18,593,862
Average per ton	$20
Treatment charges and freight	$5,047,246
Value at mine	$13,546,616
Amount received for custom work	$254,797
Total value at mine	$13,801,413
Average per mine	$293,647

Idaho.—About one-half of the mines of Idaho were placers, viz, 127, of which number 53 were operated without hired labor. The number of owners working was 92, and the average number of wage-earners employed was 199. The total value of the product was $302,175, an average of $2,379 per mine.

One-half of the deep mines were equipped with mills. These were the larger mines, the production of which averaged over $100,000 per mine. The ore treated was of a low grade, averaging about $9 per ton. The mines without mills were of the small type, with an annual product averaging less than $10,000 per mine. The ore treated by them was of a very high grade, averaging $60 per ton.

There were 10 incorporated companies which paid dividends in 1902. The total amount of dividends paid was $880,271, which was equal to 7.9 per cent on an outstanding capital stock of $11,130,420. The ore treated by these companies was of an average value of $11 per ton. The average production per mine was $358,175.

Concentration of ownership has made greater progress in Idaho than in other states. Five-eighths, $5,123,859, of the total output was contributed by 6 operators, each having an output valued at more than $500,000; one-fifth, $1,648,164, was contributed by 6 operators, each with an output valued at from $100,000 to $500,000. Very small operators, producing less than $1,000, including those from whom no individual reports were received, contributed only 1.4 per cent.

The principal statistical data for Idaho are given in the tables which follow. Table 80 is a comparative summary for deep mines operated with and without mills; Table 81 is a summary for argentiferous lead mines; Table 82 is a summary for dividend paying productive mines.

TABLE 80.—*Summary for deep mines with and without mills in Idaho: 1902.*

	Deep mines without mill connection.	Mines and mills reported jointly.	MINES AND MILLS REPORTED SEPARATELY.	
			Mines.	Mills.
Number of operators	61	20	42	....
Salaried officials, clerks, etc.:				
Number	15	96	157	35
Salaries	$18,190	$169,205	$279,182	$45,894
Wage-earners:				
Average number	183	1,148	1,633	202
Wages	$194,701	$1,339,538	$1,754,279	$232,812
Contract work	$15,171	$3,739	$17,156	....
Work on share of product	$2,455	....	....	....
Miscellaneous expenses	$20,622	$373,918	$191,544	$1,408
Cost of supplies and materials	$58,874	$669,113	$651,367	$123,161
Crude ore shipped, short tons	11,390	503	....	....
Ore treated, total, short tons	....	340,705	....	940,254
Mined and treated	....	340,705	....	939,979
Purchased ores	....	....	....	275
Value of bullion contents:				
Crude ore shipped—				
Gold	$45,330	$13	....	....
Silver	$355,353	$27,319	....	....
Lead	....	$23,113	....	....
Other metals	$286,671	....	....	....
Total	$687,354	$50,445	....	....
Average per ton	$60	$100	....	....
Treatment charges and freight	$214,787	$14,876	....	....
Value at mine	$472,567	$35,569	....	....
Ore treated—				
Gold	....	$337,867	....	$645,779
Silver	....	$1,207,250	....	$1,962,745
Lead	....	$2,500,464	....	$4,320,068
Other metals	....	$631	....	$7,086
Total	....	$4,046,212	....	$6,935,678
Average per ton	....	$12	....	$7
Treatment charges and freight	....	$1,211,537	....	$2,592,641
Value at mill	....	$2,834,675	....	$4,343,037
Cost of purchased ores, including freight	....	....	....	$2,003
Total value of product	....	$2,870,244	....	$4,341,034
Average per mill or mine	$7,747	$143,512	....	$103,357

TABLE 81.—*Summary for argentiferous lead mines in Idaho: 1902.*

Number of mines	41
Salaries	$393,293
Wages	$2,788,970
Contract work	$21,929
Miscellaneous expenses	$517,371
Cost of supplies and materials	$1,146,189
Ore treated, short tons:	
Total	1,185,710
Ore from mine	1,179,378
Custom ores	6,332
Bullion contents of product mined:	
Gold, ounces	4,634
Silver, ounces	6,287,965
Lead, pounds	208,591,226
Gold, value	$95,753
Silver, value	$3,164,384
Lead, value	$7,122,835
Other metals, value	$9,397
Total gross value	$10,392,369
Average per ton	$8.81
Value at mine	$6,414,052
Amount received for custom work	$12,946
Total value of product	$6,426,998
Average per mine	$156,756

TABLE 82.—*Summary for dividend paying productive mines in Idaho: 1902.*

Number of mines	10
Par value of stock issued	$11,130,420
Dividends	$880,271
Salaries	$231,678
Wages	$1,388,588
Contract work	$21,929
Miscellaneous expenses	$371,320
Cost of supplies and materials	$606,064
Product:	
Placer—	
Value at mine	$7,000
Deep—	
Ore mined and treated, short tons	500,670
Value of bullion contents—	
Gold	$336,350
Silver	$1,518,217
Lead	$3,707,701
Copper	$1,000
Total gross value	$5,563,268
Average per ton	$11
Treatment charges and freight	$1,988,522
Value at mine	$3,574,746
Total value of product	$3,581,746
Average per mine	$358,175

Nevada.—Nevada was at one time the principal silver mining state. The famous Comstock lode in the early days of its history furnished more than one-half of the total silver production of the United States. The flooding of the lower levels of the Comstock lode in 1886 reduced silver mining in Nevada to insignificant proportions at a time when the price of silver was nearly twice as high as in 1902. The technical progress of recent years, however, has made it possible to resume mining on the submerged levels even with the present low price of silver.

The bulk of the product mined in Nevada in 1902 was high-grade ore carrying gold and silver, and averaging $62 per ton; this ore was shipped in crude state. There were 16 mines provided with reduction plants where low-grade ore was treated.

There were 6 incorporated companies which declared dividends in 1902. The total dividends paid by them amounted to $77,602, which was equal to an average of 2.8 per cent on an outstanding capital stock with a par value of $2,748,000. The average production per mine for these companies was a little over $250,000; the ore treated by them was of a very high grade, averaging $73 per ton.

The working of the deeper mines in Nevada required a large investment of capital; hence the necessity of producing on a large scale. Three-fifths of the total yield for 1902 was produced by 5 operators, each with an output valued at $100,000 or over; the production of 1 of these 5 mines was worth over $1,000,000.

The principal statistical data for Nevada are presented in the following tables. Table 83 is a comparative summary for deep mines with and without mills, and Table 84 is a summary for dividend paying mines.

TABLE 83.—*Summary for deep mines with and without mills in Nevada: 1902.*

	Deep mines without mill connection.	Mines and mills reported jointly.	MINES AND MILLS REPORTED SEPARATELY.	
			Mines.	Mills.
Number of operators	61	7	9	9
Salaried officials, clerks, etc.:				
Number	69	24	19	8
Salaries	$98,886	$58,282	$27,675	$11,095
Wage-earners:				
Average number	471	270	188	56
Wages	$588,494	$228,755	$199,765	$61,851
Contract work	$4,650	$3,294	....	....
Work on share of product	$43,602	....	$2,000	....
Miscellaneous expenses	$121,554	$15,505	$21,381	$1,519
Cost of supplies and materials	$216,298	$143,943	$116,246	$68,140
Crude ore shipped, short tons	40,584	29	....	....
Ore treated, short tons	....	36,958	....	97,855
Value of bullion contents:				
Crude ore shipped—				
Gold	$1,028,884	$102	....	....
Silver	$1.435,090	$1,344	....	....
Other metals	$61,618	....	....	....
Total	$2,525,592	$1,446	....	....
Average per ton	$62	$50	....	....
Treatment charges and freight	$570,712	$816	....	....
Value at mine	$1,954,880	$630	....	....
Ore treated—				
Gold	....	$168,315	....	$443,087
Silver	....	$220,391	....	$79,966
Other metals	....	$2,117	....	$60
Total	....	$390,823	....	$523,113
Average per ton	....	$11	....	$5
Treatment charges and freight	....	$21,824	....	$11,413
Value at mill	....	$368,999	....	$511,700
Total value of product	$1,954,880	$369,629	....	$511,700
Average per mine or mill	$32,047	$52,804	....	$56,856

TABLE 84.—*Summary for dividend paying productive mines in Nevada: 1902.*

Number of mines	6
Par value of stock issued	$2,748,000
Dividends	$77,602
Salaries	$35,225
Wages	$283,125
Contract work	$3,294
Miscellaneous expenses	$47,183
Cost of supplies and materials	$16,704
Product:	
Placer—	
Value at mine	$4,510
Deep—	
Ore treated, short tons—	
Ore from mine	26,495
Custom ores	10,061
Value of bullion contents—	
Gold	$672,080
Silver	$1,219,649
Lead	$39,872
Other metals	$208
Total gross value	$1,931,754
Average per ton	$72.91
Treatment charges, including freight	$442,733
Value at mine	$1,489,021
Amount received for custom work	$25,158
Total value of product	$1,518,684
Average per mine	$252,362

The following is a tabular statement showing the production of the Comstock lode for 42 years, from its discovery in 1859 to the close of 1900.[1] The statistics for the earlier years are estimates based upon reports by locators and producers as substantiated by data given by millmen, and Wells, Fargo & Co., and by the county assessors' records. The results are thought to be substantially correct.

[1] Prepared by Alfred W. Doten: Report of Director of the Mint on the Production of the Precious Metals, 1900, pages 162 and 163.

Comstock total gold and silver production, from discovery and commencement: 1859 to 1900.

YEAR.	Ore (tons).	Gold, value.	Silver, value.	Total value.	Average per ton.
1859	....	$30,000.00	....	$30,000.00	....
1860	10,000	550,000.00	$200,000.00	750,000.00	$75
1861	140,000	2,500,000.00	1,000,000.00	3,500,000.00	25
1862	250,000	4,650,000.00	2,350,000.00	7,000,000.00	28
1863	450,000	4,940,000.00	7,460,000.00	12,400,000.00	28
1864	680,450	6,400,000.00	9,600,000.00	16,000,000.00	24
1865	430,745	6,133,488.00	9,700,232.00	15,833,720.00	37
1866	640,282	5,963,158.00	8,944,737.00	14,907,895.00	23
1867	462,176	5,495,443.20	8,243,164.80	13,738,608.00	30
1868	300,560	3,391,907.60	5,087,861.40	8,479,769.00	28
1869	279,584	2,962,231.20	4,443,846.80	7,405,578.00	26
1870	238,967	3,481,730.16	5,222,595.24	8,704,325.40	36
1871	409,718	4,099,811.46	6,149,717.19	10,249,528.65	25
1872	384,668	4,894,559.86	7,341,839.79	12,236,399.65	32
1873	448,301	8,668,793.40	13,003,187.13	21,671,980.53	48
1874	526,743	8,990,714.06	13,486,071.09	22,476,785.15	43
1875	546,425	10,330,208.62	15,495,312.92	25,825,521.54	47
1876	598,818	12,647,464.08	18,971,196.12	31,618,660.20	53
1877	562,519	14,520,614.68	21,780,922.02	36,301,536.70	65
1878	272,909	7,864,557.64	11,796,836.47	19,661,394.11	72
1879	178,276	2,801,394.33	4,202,091.49	7,003,485.82	39
1880	172,399	2,051,606.00	3,077,409.00	5,129,015.00	30
1881	76,049	430,248.00	645,372.00	1,075,620.00	14
1882	90,181	697,385.60	1,046,078.40	1,743,464.00	19
1883	125,914	802,539.54	1,203,809.29	2,006,348.83	16
1884	188,869	1,261,313.60	1,577,438.40	2,838,752.00	15
1885	226,147	1,729,531.25	1,415,071.04	3,144,602.29	14
1886	238,780	2,054,920.15	1,681,298.31	3,736,218.46	16
1887	223,682	2,481,176.85	2,030,053.78	4,511,230.63	20
1888	271,152	3,169,209.07	4,458,058.66	7,627,267.73	28
1889	286,144	2,590,973.32	3,358,949.95	5,949,923.27	21
1890	286,075	1,992,349.03	2,988,523.56	4,980,872.59	17
1891	188,647	1,380,857.02	2,071,285.53	3,452,142.55	18
1892	133,678	1,043,158.86	1,130,088.77	2,173,247.63	16
1893	109,780	1,123,262.54	748,841.70	1,872,104.24	17
1894	97,049	768,880.63	512,587.09	1,281,467.72	13
1895	63,558	548,873.68	365,915.79	914,789.47	14
1896	39,240	340,253.36	226,835.57	567,088.93	14
1897	17,850	223,808.63	149,205.76	373,014.39	21
1898	10,766	123,023.89	82,015.92	205,039.81	19
1899	6,780	103,006.74	68,671.16	171,677.90	25
1900	35,300	381,423.56	319,441.70	700,865.26	20
Total	10,698,681	146,613,877.61	203,636,062.84	350,249,940.45	....
Total mill tailings added	....	....	....	17,768,868.16	....
Grand total	....	....	....	368,018,808.61	....

As the above statement shows, the higher grade ores became exhausted by 1881, when the average value per ton fell by nearly one-half. There was a temporary increase in 1888 due to finds of rich ore. In 1900 the production seemed to be on the increase. The total production has been valued by some as high as $500,000,000. This lode has produced nearly as much gold as silver.

The statement below, drawn from the same source as the one preceding, shows the financial results of forty years' mining operations in the Comstock lode.[1] All the mines are arranged in three groups: (1) Those whose investments as represented by assessments were repaid by dividends. (2) Those whose dividends failed to repay assessments. (3) Those which paid no dividends.

[1] Report of Director of the Mint on the Production of the Precious Metals, 1900, page 159.

Forty years' assessments and dividends of Comstock mines.

CLASSIFICATION OF MINES WITH REGARD TO ASSESSMENTS AND DIVIDENDS.	Number of mines.	Total assessments.	Total dividends.
Total	28	$79,045,097	$133,101,590
Dividends in excess of assessments	5	10,635,650	117,620,200
Dividends short of assessments	9	40,238,684	15,481,390
No dividends paid	14	28,170,763	....

The preceding statement brings out the fact that only 5 companies returned their investment with profit; 9 companies have paid dividends, not sufficient, however, to repay for the capital invested, while one-half of the Comstock companies never recovered the capital invested. That so much capital was found for investment in obviously unprofitable ventures is thus explained by Mr. Doten: "The regular assessments levied upon the nonpaying mines were paid with the utmost facility by the market itself, delinquent assessments being immediately added to the price of the stock, fortune-blinded dealers hardly knowing or caring how it was done or who paid it, and it is to this recklessness of stock speculations that many of their mines owe their very existence to-day."

WORLD'S PRODUCTION OF GOLD AND SILVER IN 1902.

Table 85 represents the world's production of refined gold and silver in 1902, as estimated by the Director of the Mint.

It shows that as a producer of gold the United States held the second rank, being preceded by Australasia; South Africa followed next, the fourth rank was held by Russia, and the fifth by Canada. Great Britain with her colonial empire produced, in round numbers, $154,000,000, or more than one-half of the total output of the world, and the United States followed next with $80,000,000, or more than one-fourth; both nations together contributed four-fifths of the product of the gold mines of the world.

Mexico was the leading silver producing country, the output of her mines exceeding one-third of the world's production; the United States followed close behind, with one-third of the world's output. North America contributed 71.9 per cent of the world's production, and Central and South America 14.1 per cent, making for the entire American continent six-sevenths of the silver product of the world.

TABLE 85.—WORLD'S PRODUCTION OF GOLD AND SILVER FOR THE CALENDAR YEAR 1902.

[Report of the Director of the Mint, "Production of Precious Metals," 1902.]

COUNTRY.	GOLD.			SILVER.			
	Kilograms (fine).	Ounces (fine).	Value.	Kilograms (fine).	Ounces (fine).	Coining value.	Commercial value.
Total	445,215	14,313,660	$295,889,600	5,193,978	166,955,639	$215,861,800	$88,486,500
North America:							
United States	120,373	3,870,000	80,000,000	1,726,603	55,500,000	71,757,600	29,415,000
Mexico	15,279	491,156	10,153,100	1,872,091	60,176,604	77,804,100	31,893,600
Canada	31,209	1,003,355	20,741,200	133,891	4,303,774	5,564,500	2,281,000
South America:							
Argentina	45	1,451	30,000	1,174	37,720	48,800	20,000
Bolivia	7	228	4,700	404,201	12,992,641	16,798,600	6,886,100
Brazil	3,001	96,488	1,994,600				
Chile	866	27,825	575,200	110,962	3,566,792	4,611,600	1,890,400
Colombia	3,796	122,031	2,522,600	55,269	1,776,604	2,297,000	941,600
Ecuador	301	9,675	200,000	240	7,736	10,000	4,100
Guiana (British)	2,721	87,491	1,808,600				
Guiana (Dutch)	484	15,577	322,000				
Guiana (French)	3,642	117,077	2,420,200				
Peru	3,500	112,525	2,326,100	132,668	4,264,528	5,513,700	2,260,200
Uruguay	87	2,796	57,800	24	755	1,000	400
Venezuela	653	20,985	433,800	58	1,887	2,400	1,000
Central America	3,012	96,842	2,001,900	30,217	971,320	1,255,800	514,800
Europe:							
Austria-Hungary	3,267	105,037	2,171,300	58,523	1,881,132	2,432,200	997,000
Finland	2	63	1,300	269	8,679	11,200	4,600
France				11,956	384,339	496,900	203,700
Germany	94	3,023	62,500	178,032	5,722,641	7,399,000	3,033,000
Great Britain	175	5,626	116,300	5,387	173,208	223,900	91,800
Greece				33,915	1,090,188	1,409,500	577,800
Italy	8	257	5,300	30,000	964,339	1,246,800	511,100
Norway	3	97	2,000	6,422	206,418	266,900	109,400
Portugal	2	63	1,300	118	3,773	4,900	2,000
Russia	33,905	1,090,053	22,533,400	4,937	158,679	205,200	84,100
Spain	15	494	10,200	115,113	3,700,189	4,784,100	1,961,100
Sweden	94	3,023	62,500	1,439	46,226	59,800	24,500
Turkey	46	1,480	30,600	14,949	480,566	621,300	254,700
Australasia	122,749	3,946,374	81,578,800	249,690	8,026,037	10,377,100	4,253,800
Africa	58,716	1,887,773	39,023,700				
Asia:							
British India	14,428	463,824	9,588,100				
China	13,138	422,401	8,731,800				
East Indies (British)	1,545	49,686	1,027,100				
East Indies (Dutch)	850	27,312	564,600	3,679	118,302	152,900	62,700
Japan	1,936	62,259	1,287,000	12,151	390,567	505,000	207,000
Korea	5,266	169,313	3,500,000				

The following table shows the silver production of the mines and smelters of the world from 1889 to 1901. The mines of the United States and Mexico produce about two-thirds of the world's supply of silver. The United States smelts and refines all silver exported from Mexico and Canada and a portion of the production of Central and South America. Great Britain, Germany, and Belgium together import about one-half as much silver ore as the United States. The countries from which they draw their supply of ore are chiefly Australia and South America.

TABLE 86.—WORLD'S PRODUCTION OF SILVER FROM MINES AND SMELTERS: 1889 TO 1901.

[Figures for 1898 to 1901 from "Lead, Copper, Spelter, Tin, Silver, Nickel, Aluminum, and Quicksilver," compiled by Metallgesellschaft and Metallurgische Gesellschaft, A.-G., Frankfort-on-the-Main, October, 1903; those for 1889 to 1892 from "Summary of the Statistical Report of the Metallgesellschaft."]

[Metric tons.]

COUNTRY.	1901				1900				1899			
	Product of smelters.	Product of mines.	Excess of product of smelters over mines.	Excess of product of mines over smelters.	Product of smelters.	Product of mines.	Excess of product of smelters over mines.	Excess of product of mines over smelters.	Product of smelters.	Product of mines.	Excess of product of smelters over mines.	Excess of product of mines over smelters.
Total production	5,511.6	5,444.1	2,124.7	2,057.2	5,613.0	5,400.3	2,251.2	2,038.5	5,277.0	5,237.1	1,967.5	1,927.6
Europe	1,134.6	438.6	749.2	53.2	1,114.0	421.6	729.4	37.0	1,140.8	428.1	752.9	40.2
Germany	403.8	171.8	232.0	....	415.7	168.4	247.8	....	467.6	194.2	273.4	....
Great Britain	283.9	6.9	277.0	....	266.0	6.9	259.1	....	275.0	5.8	269.2	....
Belgium	167.0	....	167.0	....	143.0	....	143.0	....	120.9	....	120.9	....
Spain and Portugal	95.0	99.2	....	4.2	99.9	99.2	0.7	....	88.4	76.4	12.0	....
France	77.5	14.1	63.4	....	85.6	14.1	71.5	....	82.1	14.5	67.6	....
Austria-Hungary	62.8	62.1	0.7	....	59.8	61.9	....	2.1	60.6	59.0	1.6	....
Italy	32.5	23.4	9.1	....	31.2	23.4	7.8	....	33.6	25.5	8.1	....
Greece	....	35.9	....	35.9	....	31.5	....	31.5	....	36.7	....	36.7
Turkey	1.5	13.4	....	11.9	1.5	4.4	....	2.9	1.5	4.4	....	2.9
Norway	4.0	5.2	....	1.2	5.0	5.4	....	0.4	4.6	4.5	0.1	....
Russia	4.9	4.9	....	....	4.4	4.5	....	0.1	4.2	4.2	....	....
Sweden	1.7	1.7	....	....	1.9	1.9	....	....	2.8	2.3	....	....
Servia	....	....	....	....	....	....	....	....	....	0.6	....	0.6
America	4,138.0	4,543.2	1,370.3	1,775.5	4,260.0	4,507.4	1,516.6	1,764.0	3,915.0	4,359.8	1,211.3	1,656.1
United States	3,088.0	1,717.7	1,370.3	....	3,310.0	1,793.4	1,516.6	....	2,915.0	1,703.7	1,211.3	....
Mexico	750.0	1,793.7	....	1,043.7	650.0	1,786.9	....	1,136.9	700.0	1,730.1	....	1,030.1
Central and South America	300.0	868.7	....	568.7	300.0	788.7	....	488.7	300.0	819.9	....	519.9
Canada	....	163.1	....	163.1	....	138.4	....	138.4	....	106.1	....	106.1
Australia	180.0	406.0	....	226.0	180.0	415.0	....	235.0	165.0	396.3	....	231.3
Japan	59.0	53.8	5.2	....	59.0	53.8	5.2	....	56.2	52.9	3.3	....
East Indies	....	2.5	....	2.5	....	2.5	....	2.5	....	....	....	....

COUNTRY.	1898				1897				1896			
	Product of smelters.	Product of mines.	Excess of product of smelters over mines.	Excess of product of mines over smelters.	Product of smelters.	Product of mines.	Excess of product of smelters over mines.	Excess of product of mines over smelters.	Product of smelters.	Product of mines.	Excess of product of smelters over mines.	Excess of product of mines over smelters.
Total production	5,324.1	5,259.3	1,978.0	1,913.2	5,360.6	4,990.6	2,049.0	1,679.0	5,258.8	4,886.2	1,658.4	1,286.8
Europe	1,215.6	415.1	846.6	46.1	1,240.2	408.9	873.3	42.0	1,076.8	528.6	674.5	126.3
Germany	480.6	173.3	307.3	....	448.0	171.0	277.0	....	428.4	183.3	245.1	....
Great Britain	310.0	6.6	303.4	....	375.0	7.2	367.8	....	310.0	8.2	301.8	....
Belgium	100.6	....	100.6	....	75.7	....	75.7	....	59.4	....	59.4	....
Spain and Portugal	114.0	76.4	37.6	....	131.0	71.2	59.8	....	92.0	179.8	....	87.8
France	90.9	14.3	76.6	....	80.4	16.9	63.5	....	70.5	16.4	54.1	....
Austria-Hungary	59.1	56.4	2.7	....	66.8	61.3	5.5	....	59.7	58.0	1.7	....
Italy	43.4	25.0	18.4	....	45.3	22.9	22.4	....	38.1	27.2	10.9	....
Greece	....	42.0	....	42.0	....	37.4	....	37.4	....	32.0	....	32.0
Turkey	1.5	4.4	....	2.9	1.5	4.4	....	2.9	1.5	7.0	....	5.5
Norway	4.8	5.4	....	0.6	5.4	6.5	....	1.1	4.7	5.0	....	0.3
Russia	8.7	8.7	....	....	8.9	8.9	....	....	10.4	10.5	....	0.1
Sweden	2.0	2.0	....	....	2.2	0.6	1.6	....	2.1	0.6	1.5	....
Servia	....	0.6	....	0.6	....	0.6	....	0.6	....	0.6	....	0.6
America	3,875.0	4,457.2	1,131.4	1,713.6	3,850.0	4,157.8	1,174.4	1,482.2	3,864.0	3,912.6	983.7	1,032.3
United States	2,825.0	1,693.6	1,131.4	....	2,850.0	1,675.6	1,174.4	....	2,814.0	1,830.3	983.7	....
Mexico	750.0	1,765.1	....	1,015.1	700.0	1,677.0	....	977.0	750.0	1,422.8	....	672.8
Central and South America	300.0	860.0	....	560.0	300.0	632.3	....	332.3	300.0	560.3	....	260.3
Canada	....	138.5	....	138.5	....	172.9	....	172.9	....	99.7	....	99.7
Australia	173.0	326.4	....	153.4	214.7	369.5	....	154.8	253.0	380.7	....	127.7
Japan	60.5	60.6	....	0.1	55.7	54.4	1.3	....	64.5	64.3	0.2	....
East Indies	....	....	....	....	....	....	....	....	....	....	....	....

TABLE 86.—WORLD'S PRODUCTION OF SILVER FROM MINES AND SMELTERS: 1889 TO 1901—Continued.

COUNTRY.	1895				1894				1893			
	Product of smelters.	Product of mines.	Excess of product of smelters over mines.	Excess of product of mines over smelters.	Product of smelters.	Product of mines.	Excess of product of smelters over mines.	Excess of product of mines over smelters.	Product of smelters.	Product of mines.	Excess of product of smelters over mines.	Excess of product of mines over smelters.
Total production	5,233.2	5,210.9	1,519.6	1,497.3	5,409.5	5,121.0	1,641.5	1,353.0	5,434.5	5,147.8	1,475.6	1,188.9
Europe	1,156.2	454.0	781.2	79.0	1,420.2	456.1	1,033.7	60.6	1,397.1	494.0	939.0	35.9
Germany	392.0	181.0	211.0		444.2	193.0	251.2		449.3	179.0	270.3	
Great Britain	420.0	8.7	411.3		600.0	7.9	592.1		600.0	7.9	592.1	
Belgium	66.9		66.9		67.0		67.0		62.7		62.7	
Spain and Portugal	83.0	109.8		26.8	85.0	63.6	21.4		62.6	62.6		
France	71.1	17.6	53.5		97.0	26.1	70.9		98.1	98.1		
Austria-Hungary	60.5	67.9		7.4	58.3	83.5		25.2	61.2	90.1		28.9
Italy	44.2	5.7	38.5		58.6	28.9	29.7		40.1	28.9	11.2	
Greece		35.4		35.4		35.4		35.4		2.0		2.0
Turkey	1.5	8.1		6.6	1.5	1.5			1.3	6.3		5.0
Norway	5.0	6.1		1.1	4.8	4.7	0.1		4.8	4.5	0.3	
Russia	10.8	12.5		1.7	9.9	8.6	1.3		12.5	10.1	2.4	
Sweden	1.2	1.2			2.9	2.9			4.5	4.5		
Servia												
America	3,767.0	4,300 4	733.3	1,266.7	3,698.1	4,041.7	596.5	940.1	3,781.0	3,958.0	525.2	702.2
United States	2,467.0	1,733.7	733.3		2,136.4	1,539.9	596.5		2,391.8	1,866.6	525.2	
Mexico	800.0	1,461.0		661.0	1,061.7	1,463.4		401.7	889.2	1,380.1		490.9
Central and South America	500.0	1,050.5		550.5	500.0	1,012.0		512.0	500.0	703.6		203.6
Canada		55.2		55.2		26.4		26.4		7.7		7.7
Australia	237.5	389.1		151.6	210.0	562.3		352.3	187.0	637.8		450.8
Japan	72.5	67.4	5.1		72.2	60.9	11.3		69.4	58.0	11.4	
East Indies												

COUNTRY.	1892				1891				1890				1889			
	Product of smelters.	Product of mines.	Excess of product of smelters over mines.	Excess of product of mines over smelters.	Product of smelters.	Product of mines.	Excess of product of smelters over mines.	Excess of product of mines over smelters.	Product of smelters.	Product of mines.	Excess of product of smelters over mines.	Excess of product of mines over smelters.	Product of smelters.	Product of mines.	Excess of product of smelters over mines.	Excess of product of mines over smelters.
Total production	5,158.0	4,757.7	1,264.8	864.5	4,805.0	4,267.8	1,207.8	670.6	4,386.7	4,144.1	918.0	675.4	4,175.5	3,900.9	903.5	628.9
Europe	1,362.5	478.6	896.0	12.1	1,340.5	424.4	924.1	8.0	1,086.7	400.5	692.7	6.5	1,082.2	409.2	673.0	
Germany	487.8	212.1	275.7		444.9	186.6	258.3		402.9	182.1	220.8		403.0	192.8	210.2	
Great Britain	540.0	5.3	534.7		600.0	6.1	593.9		400.0	9.1	390.9		380.0	9.5	370.5	
Belgium	57.0		57.0		56.0		56.0		54.0		54.0		42.6		42.6	
Spain and Portugal	55.7	46.3	9.4		51.5	46.3	5.2		46.0	51.5		5.5	65.0	51.5	13.5	
France	103.2	92.7	10.5		71.3	64.2	7.1		71.1	71.1			80.9	80.9		
Austria-Hungary	55.0	55.1		0.1	53.0	52.0	1.0		53.0	50.6	2.4		52.6	52.6		
Italy	43.0	39.8	3.2		37.6	37.6			34.4	10.1	24.3		33.5	8.1	25.4	
Greece		2.0		2.0		2.0		2.0								
Turkey	1.3	6.3		5.0	1.3	6.3		5.0	1.3	1.3			1.3	1.3		
Norway	4.8	4.5	0.3		4.7	5.7		1.0	5.0	5.5		0.5	5.3	5.1	0.2	
Russia	9.5	14.5		5.0	14.5	13.9	0.6		14.5	15.0		0.5	13.8	3.2	10.6	
Sweden	5.2		5.2		5.7	3.7	2.0		4.5	4.2	0.3		4.2	4.2		
Servia																
America	3,684.8	3,806.0	368.8	490.0	3,376.0	3,489.0	283.7	396.7	3,192.6	3,442.9	214.9	465.2	3,050.3	3,244.2	230.5	424.4
United States	2,344.3	1,975.5	368.8		2,098.3	1,814.6	283.7		1,910.4	1,695.5	214.9		1,785.9	1,555.4	230.5	
Mexico	840.5	1,228.9		388.4	777.7	1,084.1		306.4	832.2	1,211.6		379.4	814.4	1,143.9		329.5
Central and South America	500.0	590.9		90.9	500.0	580.5		80.5	450.0	523.3		73.3	450.0	533.0		83.0
Canada		10.7		10.7		9.8		9.8		12.5		12.5		11.9		11.9
Australia	75.0	418.1		343.1	45.5	311.1		265.6	54.5	258.2		203.7		204.5		204.5
Japan	35.7	55.0		19.3	43.0	43.3		0.3	52.9	42.5	10.4		43.0	43.0		
East Indies																

PRODUCTION OF LEAD.

Lead contents of ores smelted in the United States, 1894 to 1902.—A considerable part of the value of the total output of silver mines is the value of the lead contents of their ores. In many cases the value of the lead contained determines whether or not an ore can be mined with profit; and, therefore, statistics of lead are of direct interest in connection with silver.

About three-fourths of the entire output of refined lead in the United States is obtained from silver bearing ores, as appears from the following table. The ores of Missouri, Kansas, Wisconsin, Illinois, Iowa, Virginia, and Kentucky are nonargentiferous; all others are argentiferous.

TABLE 87.—LEAD CONTENTS OF ORES SMELTED BY THE WORKS IN THE UNITED STATES, BY STATES AND TERRITORIES: 1894 TO 1902.

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

[Short tons.]

STATE OR TERRITORY.	1902	1901	1900	1899	1898	1897	1896	1895	1894
Total lead contents American ores smelted	280,797	284,204	...	230,090	235,573	222,499	197,496	182,331	170,383
Colorado	51,833	73,265	82,137	70,308	57,352	40,576	44,803	46,984	50,613
Idaho	84,742	79,654	85,444	52,154	59,142	58,627	46,662	31,638	33,308
Utah	53,914	49,870	48,044	29,987	39,299	40,537	35,578	31,305	23,190
Montana	4,438	5,791	...	10,227	10,745	12,930	11,070	9,802	9,637
New Mexico	741	1,124	...	4,856	5,797	9,123	3,461	3,040	2,973
Nevada	1,269	1,873	...	3,388	4,714	959	1,173	2,583	2,254
Arizona	599	4,045	...	3,377	2,224	2,184	1,165	2,053	1,480
California	175	881	520	487	482	383	691	949	478
Washington	1,457								
Oregon, Alaska, South Dakota, Texas	2,184	1,029	...	862	1,349	638	1,006	381	150
Missouri, Kansas, Wisconsin, Illinois, Iowa, Virginia, and Kentucky	79,445	67,172	...	54,444	54,469	56,542	51,887	53,596	46,300

World's production and consumption of lead, 1889 to 1902.—The following table shows the world's production and consumption of lead, by countries, from 1889 to 1902:

TABLE 88.—WORLD'S PRODUCTION AND CONSUMPTION OF LEAD: 1889 TO 1902.

[Production figures from "Lead, Copper, Spelter, Tin, Silver, Nickel, Aluminum, and Quicksilver," compiled by Metallgesellschaft and Metallurgische Gesellschaft A.-G., Frankfort-on-the-Main, October, 1903. Consumption figures from 1889 and 1892 from "Summary of the Statistical Report of the Metallgesellschaft;" those for 1893 to 1902 from "Metallgesellschaft and Metallurgische Gesellschaft," October, 1903.]

[Metric tons.]

COUNTRY.	1902				1901				1900			
	Production.	Consumption.	Excess of consumption over production.	Excess of production over consumption.	Production.	Consumption.	Excess of consumption over production.	Excess of production over consumption.	Production.	Consumption.	Excess of consumption over production.	Excess of production over consumption.
Total	863,300	859,026	369,226	373,500	839,000	832,721	350,000	356,279	833,400	834,593	353,428	352,150
North America:												
United States	242,700	267,675	24,975	...	245,600	257,351	11,751	...	251,000	264,223	13,223	...
Mexico[1]	102,000	...	...	102,000	89,300	...	...	89,300	90,500	...	...	90,500
Canada[2]	8,900	...	...	8,900	23,700	...	...	23,700	19,200	...	...	19,200
Europe:												
Spain	172,200	...	...	172,200	149,500	...	...	149,500	154,500	...	...	154,500
Germany	140,300	156,237	15,937	...	123,100	155,164	32,064	...	121,500	172,855	51,440	...
Great Britain	27,100	238,214	211,114	...	35,600	225,602	190,002	...	35,500	202,855	167,355	...
Italy	26,400	28,273	1,873	...	26,200	24,621	...	1,579	23,800	22,150	...	1,650
Belgium	19,500	22,500	3,000	...	19,500	20,900	1,400	...	16,400	23,000	6,600	...
France	18,500	84,386	65,886	...	20,000	85,636	65,636	...	17,000	94,254	77,254	...
Greece	15,900	...	...	15,900	17,700	...	...	17,700	16,800	...	...	16,800
Austria-Hungary	12,500	21,153	8,653	...	12,200	22,877	10,677	...	12,700	20,286	7,586	...
Russia	...	28,300	23,300	...	...	23,000	23,000	...	...	20,300	20,300	...
Netherlands	...	5,000	5,000	...	...	5,000	5,000	...	...	5,000	5,000	...
Switzerland	...	3,288	3,288	...	...	3,470	3,470	...	...	3,170	3,170	...
Other European countries[3]	4,900	2,700	...	2,200	4,300	1,800	...	2,500	4,500	2,000	...	2,500
Australia[4]	72,300	...	...	72,300	72,000	...	...	72,000	67,000	...	...	67,000
All other countries[5]	100	6,300	6,200	...	300	7,300	7,000	...	3,000	4,500	1,500	...

COUNTRY.	1899				1898				1897			
	Production.	Consumption.	Excess of consumption over production.	Excess of production over consumption.	Production.	Consumption.	Excess of consumption over production.	Excess of production over consumption.	Production.	Consumption.	Excess of consumption over production.	Excess of production over consumption.
Total	783,600	778,446	340,946	346,100	797,700	783,719	325,815	339,796	702,000	709,912	307,416	299,504
North America:												
United States	197,000	216,406	19,406	...	207,300	218,628	11,328	...	179,400	207,617	28,217	...
Mexico[1]	86,500	...	...	86,500	70,600	...	...	70,600	69,900	...	...	69,900
Canada[2]	8,100	...	...	8,100	15,000	...	...	15,000	17,000	...	...	17,000
Europe:												
Spain	162,900	...	...	162,900	180,500	...	...	180,500	171,700	...	...	171,700
Germany	129,200	160,369	31,169	...	132,700	155,372	22,672	...	118,900	129,898	10,998	...
Great Britain	42,000	205,444	163,444	...	50,000	212,163	162,163	...	40,000	182,834	142,834	...
Italy	20,500	22,036	1,536	...	24,500	20,104	...	4,396	22,400	20,796	...	1,604
Belgium	15,700	20,700	5,000	...	19,300	20,700	1,400	...	17,000	20,400	3,400	...
France	16,900	93,286	76,386	...	10,900	91,423	80,523	...	9,900	86,739	76,839	...
Greece	18,400	...	...	18,400	19,200	...	...	19,200	16,000	...	...	16,000
Austria-Hungary	11,900	20,605	8,705	...	12,600	22,038	9,438	...	12,200	18,038	5,838	...
Russia	...	28,300	23,300	...	...	22,650	22,650	...	...	24,750	24,750	...
Netherlands	...	5,000	5,000	...	...	5,000	5,000	...	...	5,000	5,000	...
Switzerland	...	2,700	2,700	...	...	3,441	3,441	...	...	2,640	2,640	...
Other European countries[3]	4,300	2,100	...	2,200	3,800	3,700	...	100	3,600	2,300	...	1,300
Australia[4]	68,000	...	...	68,000	50,000	...	...	50,000	22,000	...	...	22,000
All other countries[5]	2,200	6,500	4,300	...	1,300	8,500	7,200	...	2,000	9,400	7,400	...

[1] For production, includes lead contents of the ores exported.

[2] For production, the figures comprise the lead obtained from Canada ores in the United States, as well as the Canadian exports of argentiferous lead which were not imported till 1900, in which year, however, the amount rose to 10,000 tons; for 1901 and 1902 no figures were obtainable.

[3] For production, Russia, Scandinavia, and Turkey.

[4] For production, such as was not exported to Europe and America has not been taken into account here. The total production of Australia amounted in 1902 to 90,000; 1901, to 90,000; 1900, to 87,100; 1899, to 87,600; and in 1898, to about 67,000 metric tons. The exports of lead from Australia to eastern Asia amounted to about 11,700 in 1902, 9,100 in 1901, and 12,500 metric tons in 1900.

[5] For production, imports from Chile, Peru, East India, and Africa to Europe, according to European Trade Statistics.

TABLE 88.—WORLD'S PRODUCTION AND CONSUMPTION OF LEAD: 1889 TO 1902—Continued.

COUNTRY.	1896				1895				1894			
	Production.	Consumption.	Excess of consumption over production.	Excess of production over consumption.	Production.	Consumption.	Excess of consumption over production.	Excess of production over consumption.	Production.	Consumption.	Excess of consumption over production.	Excess of production over consumption.
Total	677,100	675,889	286,056	287,267	638,000	656,851	303,705	284,854	621,800	629,877	289,399	281,322
North America:												
United States	158,500	179,801	21,301		142,300	214,459	72,159		146,400	173,413	27,013	
Mexico[1]	63,300			63,300	68,000			68,000	57,000			57,000
Canada[2]	9,000			9,000	4,300			4,300				
Europe:												
Spain	168,600			168,600	154,500			154,500	159,300			159,300
Germany	113,800	121,980	8,180		111,000	111,652	652		101,000	100,678		322
Great Britain	57,200	196,200	139,000		45,500	170,130	124,630		39,700	161,847	122,147	
Italy	20,800	20,533		267	20,400	19,146		1,254	19,600	19,947	347	
Belgium	17,200	18,800	1,600		15,600	17,094	1,494		14,100	22,478	8,378	
France	8,200	77,776	69,576		7,600	64,657	57,057		8,800	86,160	77,360	
Greece	14,700			14,700	16,800			16,800	12,700			12,700
Austria-Hungary	11,700	18,814	7,114		10,400	19,276	8,876		9,700	18,442	8,742	
Russia		20,300	20,300			21,400	21,400			26,700	26,700	
Netherlands		5,000	5,000			5,000	5,000			5,000	5,000	
Switzerland		2,485	2,485			1,837	1,837			1,412	1,412	
Other European countries[3]	3,500	2,100		1,400	3,600	1,600		2,000	3,500	1,500		2,000
Australia[4]	30,000			30,000	38,000			38,000	50,000			50,000
All other countries[5]	600	12,100	11,500			10,600	10,600			12,300	12,300	

COUNTRY.	1893				1892				1891			
	Production.	Consumption.	Excess of consumption over production.	Excess of production over consumption.	Production.	Consumption.	Excess of consumption over production.	Excess of production over consumption.	Production.	Consumption.	Excess of consumption over production.	Excess of production over consumption.
Total	627,600	635,732	301,761	293,629	629,200	634,530	282,935	277,605	598,800	619,760	272,892	251,932
North America:												
United States	151,700	179,163	27,463		166,200	191,728	25,528		160,800	181,842	21,042	
Mexico[1]	64,000			64,000	47,500			47,500	30,200			30,200
Canada[2]												
Europe:												
Spain	157,100			157,100	153,300			153,300	145,700			145,700
Germany	95,000	94,571		429	98,000	89,595		8,405	95,000	88,268		6,732
Great Britain	36,300	178,415	142,115		42,800	174,974	132,174		48,200	175,851	127,651	
Italy	19,900	19,985	85		22,000	22,787	787		18,500	22,552	4,052	
Belgium	12,000	23,088	11,088		10,100	13,779	3,679		12,700	19,834	7,134	
France	8,100	77,065	68,965		8,800	73,545	64,745		6,700	70,664	63,964	
Greece	12,800			12,800	14,400			14,400	13,300			13,300
Austria-Hungary	9,700	15,604	5,904		9,600	16,600	7,000		9,700	14,011	4,311	
Russia		24,500	24,500			22,100	22,100			17,400	17,400	
Netherlands		5,000	5,000			5,000	5,000			5,000	5,000	
Switzerland		1,941	1,941			1,922	1,922			1,738	1,738	
Other European countries[3]	3,000	1,700		1,300	2,500	2,700	200		2,000	2,300	300	
Australia[4]	58,000			58,000	54,000			54,000	56,000			56,000
All other countries[5]		14,700	14,700			19,800	19,800			20,300	20,300	

COUNTRY.	1890				1889			
	Production.	Consumption.	Excess of consumption over production.	Excess of production over consumption.	Production.	Consumption.	Excess of consumption over production.	Excess of production over consumption.
Total	539,500	569,048	265,416	235,868	549,200	570,199	256,579	235,580
North America:								
United States	129,300	154,823	25,523		143,200	167,758	24,558	
Mexico[1]	22,300			22,300	27,500			27,500
Canada[2]								
Europe:								
Spain	140,300			140,300	136,900			136,900
Germany	101,000	82,432		18,568	100,000	77,320		22,680
Great Britain	48,500	159,832	111,332		47,600	153,087	105,487	
Italy	17,700	19,733	2,033		18,200	23,837	5,637	
Belgium	9,600	19,738	10,138		9,400	19,712	10,312	
France	4,600	62,352	57,752		5,400	57,510	52,110	
Greece	14,200			14,200	13,500			13,500
Austria-Hungary	9,500	12,785	3,285		10,500	13,275	2,775	
Russia		18,800	18,800			16,000	16,000	
Netherlands		5,000	5,000			5,000	5,000	
Switzerland		2,753	2,753			2,400	2,400	
Other European countries[3]	2,000	2,200	200		2,000	3,500	1,500	
Australia[4]	40,500			40,500	35,000			35,000
All other countries[5]		28,600	28,600			30,800	30,800	

[1] For production, includes lead contents of the ores exported.

[2] For production, the figures comprise the lead obtained from Canada ores in the United States, as well as the Canadian exports of argentiferous lead which were not imported till 1900, in which year, however, the amount rose to 10,000 tons; for 1901 and 1902 no figures were obtainable.

[3] For production, Russia, Scandinavia, and Turkey.

[4] For production, such as was not exported to Europe and America has not been taken into account here. The total production of Australia amounted in 1902 to 90,000; 1901, to 90,000; 1900, to 87,100; 1899, to 87,600; and in 1898, to about 67,000 metric tons. The exports of lead from Australia to eastern Asia amounted to about 11,700 in 1902, 9,100 in 1901, and 12,500 metric tons in 1900.

[5] For production, imports from Chile, Peru, East India, and Africa to Europe, according to European Trade Statistics.

DIAGRAM V.—VARIATION OF THE COMMERCIAL RATIO OF SILVER TO GOLD SINCE 1700.

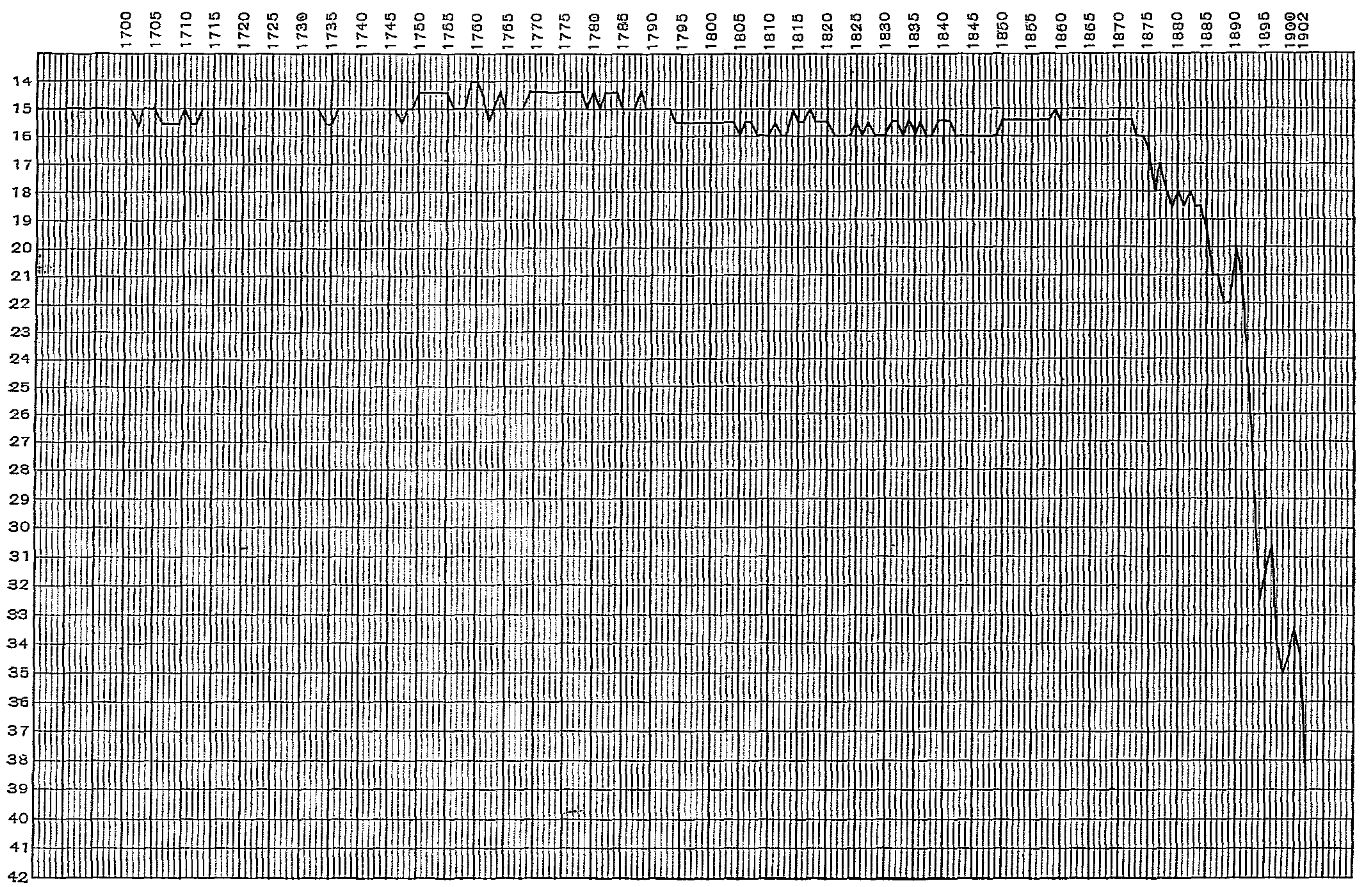
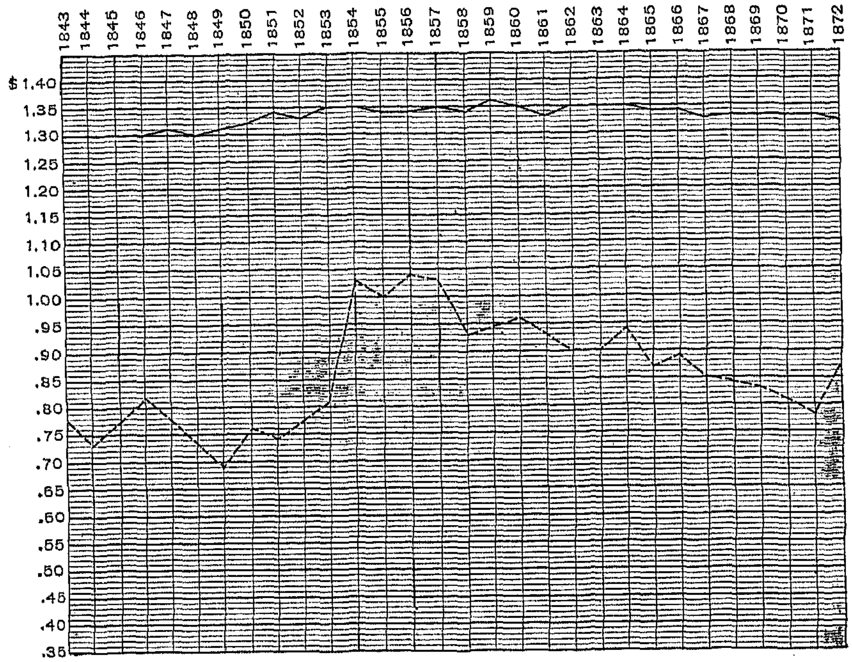
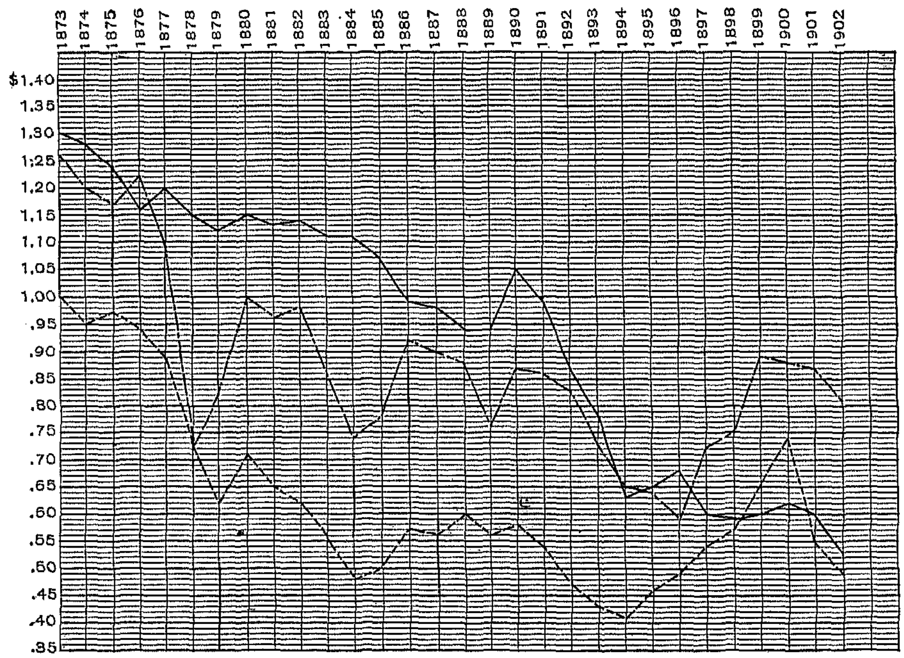


DIAGRAM VI.—PRICES OF SILVER AND LEAD IN THE LONDON MARKET: 1843 TO 1872.



——— AVERAGE PRICES OF SILVER, CENTS PER OUNCE.
– – – – AVERAGE PRICES OF LEAD, CENTS PER UNIT OF 20 POUNDS, IN LONDON MARKET.

DIAGRAM VII.—PRICES OF SILVER AND LEAD IN THE LONDON MARKET, AND LEAD IN THE NEW YORK MARKET: 1873 TO 1902.



——— AVERAGE PRICES OF SILVER, CENTS PER OUNCE.
–·–·–·– AVERAGE PRICES OF LEAD, CENTS PER UNIT OF 20 POUNDS, IN NEW YORK MARKET.
– – – – AVERAGE PRICES OF LEAD, CENTS PER UNIT OF 20 POUNDS, IN LONDON MARKET.

The foregoing table shows that the United States is both the largest producer and the largest consumer of lead. Spain, Germany, Mexico, and Australia, respectively, rank next as producers, while Great Britain, Germany, and France follow in this order as consumers. More than one-half of the world's lead output is consumed in the lead producing countries, less than one-half being an article of international commerce. The largest producer for the world's market is Spain, which furnished in 1902 about one-half of the supply; next after Spain follows Mexico, and the third place is occupied by Australia. These three countries together furnish the supply for about nine-tenths of the international demand for lead. The largest consumer of imported lead is Great Britain, which in 1902 consumed more than one-half of the international supply. The second place is held by France. The two countries together have imported within late years from two-thirds to three-fourths of the entire quantity sold in the world's market. The United States produces lead for home consumption only, and imports a comparatively small proportion for the same purpose; but a considerable quantity of lead ores and base bullion is imported from Mexico and British America, refined in bond, and reexported.

The following table shows, by years, the share of the United States in the lead exports of Mexico and British America. The first column represents the excess of the product of Mexico and British America over their consumption, as shown in the preceding table, the quantities being reduced from metric to short tons. The second column represents the production of refined lead in the United States from foreign ores and base bullion, less the imports of ore and base bullion from other countries than the two above named; both quantities are taken from the estimates of the United States Geological Survey.

TABLE 89.—*Total exports of lead ore and base bullion from Mexico and British America, and exports from those countries to the United States: 1889 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR.	TOTAL EXPORTS.	EXPORTS TO THE UNITED STATES.	
	Short tons.	Short tons.	Per cent of total exports.
1902	122, 212	98, 008	80. 2
1901	124, 526	108, 281	87. 0
1900	120, 889	103, 281	85. 4
1899	104, 249	95, 355	91. 5
1898	94, 331	99, 705	105. 7
1897	95, 764	82, 891	86. 6
1896	79, 675	76, 910	96. 5
1895	79, 675	75, 707	95. 0
1894	62, 814	59, 739	95. 1
1893	70, 528	65, 851	92. 7
1892	52, 845	39, 957	76. 3
1891	33, 280	23, 852	71. 7
1890	24, 575	18, 124	73. 7
1889	30, 305	26, 570	87. 7

The preceding table shows that the United States received about nine-tenths of the exports from Mexico and British America. In 1898 the lead product smelted in the United States from Mexican and Canadian ores exceeded the total exports from those countries; this is explained by the fact that a portion of the ore smelted during that year had been exported during the year previous.

Prices of silver and lead.—Diagram V shows the annual fluctuations of the commercial ratio of gold to silver since the beginning of the eighteenth century. The fluctuations in the price of an ounce of standard silver, 0.925 fine, in the London market in 1901 and 1902 are shown in the following statement:[1]

Prices of silver in London by months: 1902 and 1901.

	1902	1901
	d.	d.
January	25. 69	28. 98
February	25. 42	28. 14
March	25. 01	27. 94
April	24. 82	27. 30
May	23. 70	27. 45
June	24. 17	27. 42
July	24. 38	26. 96
August	24. 23	26. 94
September	23. 88	26. 96
October	23. 40	26. 61
November	22. 69	26. 09
December	22. 21	25. 44

Diagrams VI and VII show the fluctuations of the prices of silver and lead for two periods of equal length divided by the year 1873, when silver began to decline in value. Diagram VI shows the prices in the London market of an ounce of fine silver and of a unit of 20 pounds of lead. Diagram VII shows the London prices of silver and lead and the New York price of lead since 1873.

An examination of the diagrams shows that the prices of lead and silver move in different directions: though the bulk of silver as well as of lead in the United States is smelted from ores where both metals occur together, yet their price movements in the United States show no similarity; on the other hand, the movements of the London and the New York price of lead are approximately parallel.

Tables 90 and 91 are detailed summaries of the statistics for gold and silver mines for 1902, the former for producing mines, the latter for mines at which the work was only development.

DESCRIPTIVE.

The production of gold and silver antedates the dawn of written history. The search for the precious metals prompted the discovery of new continents and stimulated the efforts of the alchemists, thus indirectly lead-

[1] "Comparative Statistics of Lead, Copper, Spelter, Tin, Silver, Nickel, Aluminum, and Quicksilver," compiled by Metallgesellschaft and Metallurgische Gesellschaft, A.-G., Frankfort-on-the-Main, October, 1903.

ing to the development of scientific chemistry. Yet it is only since the beginning of gold mining in English-speaking countries, at about the middle of the nineteenth century, that any progress in mining methods can be recorded. And even to-day, notwithstanding the technical advance of the last half century, mining methods of primitive man can be observed in actual operation in some parts of the United States.

Placer mines.—The earliest form of gold mining is the working of alluvial mines or "placers," where the gold has been reduced by the operation of the forces of nature to fine dust mixed with gravel. The work left for the miner is to separate by washing the particles of gold from the surrounding mass of sand and gravel. The final product of the mine is gold.

The pioneers of gold mining in the United States had no experience to guide them but that of the Latin-American countries. The results accomplished by the Spaniards were extremely meager. Mr. T. Wain-Morgan Draper, writing in the Engineering and Mining Journal concerning the gold deposits in Ecuador and Colombia, cites the example of one property which was worked extensively with numerous slaves for over one hundred years. A careful examination and measurement of the work accomplished shows that half a dozen 4-inch "giants" would do as much in one year's time. No such results could be accomplished by the Spaniards with their tiny reservoirs, which, when filled with rain water, were turned loose to wash the gravel down a rock sluice.[1] During the canvass of 1903 there was found in Arizona a placer field of 7,000 acres, divided into numerous claims, worked by Mexicans, where not only was all work done by hand, but even the water was packed or hauled from a distance of 6 or 8 miles.

The beginning of gold mining in the United States dates back to the first quarter of the nineteenth century, when some placer mining was done in North Carolina and Georgia. The settlers worked at odd moments singly or in small gangs, giving to mining such time as they could spare from other occupations. The workings were largely executed by slave labor and were confined chiefly to surface mining.

The gold pan, the long tom, the rocker, and the pick and shovel constituted the miner's outfit. These simple methods still survive wherever placers are worked by miners with practically no capital and without hired labor. It may be fairly estimated that most of the placer gold mined in the Western states and Alaska is produced in this time honored fashion. The following extract, descriptive of placer mining as it was conducted in Alaska as late as 1900, is quoted from an official report:[2]

The mining on the beach is the simplest operation possible, a rocker being all that is required in addition to a shovel and a pick and a good, strong back. The dirt is shoveled up and thrown onto a coarse screen, which removes the larger stones and trash, the latter derived from the driftwood, etc., from the sea. The fine dirt passes over a series of riffles, which are small obstructions, and is finally washed off, leaving the heavy gold. In some cases the tailings pass over a small piece of carpet or burlap, in other cases an amalgamated silver plate is used; but in each case the object is the same, viz, to catch the fine gold. The heavy particles of gold are caught in the riffles, while the fine either amalgamates or is retained by the carpet, while the lighter material or tailings is washed away.

Soon after the discovery of gold in California, however, the inventive genius of the American miner devised a simple but effective way of working placer mines. The first hydraulic apparatus for working placer mines was introduced in the spring of 1852 by a miner, whose name is not remembered, at his claim at Yankee Jim, Placer county, California.

This machine was very simple. From a small ditch on the hillside a flume was built toward the ravine, where the mine was opened. The flume gained height above the ground as the ravine was approached, until finally a "head," or vertical height, of 40 feet was reached. At this point the water was discharged into a barrel, from the bottom of which depended a hose, about 6 inches in diameter, made of common cowhide, and ending in a tin tube about 4 feet long, the latter tapering down to a final opening or nozzle of 1 inch. This was the first hydraulic apparatus in California, simple in design, dwarfish in size, yet destined to grow out of its insignificance into a giant powerful enough to move mountains from their foundations. The news spread among the miners, the wonderful practicability of the new invention was at once acknowledged, and, wherever circumstances permitted, a "hydraulic," the name adopted for the novel apparatus, was rigged.[3]

The original idea was much improved upon in the course of time, and the hydraulic method proved a great labor saver, as compared with the primitive pan, rocker, and sluice. The decline of hydraulic mining within the last twenty years is the outcome of a long conflict between the farming and mining interests in California, which has resulted in the débris legislation for the protection of navigable rivers and farming lands. Hydraulic mining requires great space for dumping the masses of earth which are removed from their original position. Formerly, after a bank had been broken up and the gold washed out, the easiest way to get rid of the "tailings" was to discharge them into the nearest stream. With the extension of hydraulic mining the rivers were soon overfilled with débris, which settled in their beds and was deposited all along their course, causing considerable damage to abutting farm lands. An act of Congress was passed in 1893 which requires débris or tailings of all mines operating in the drainage basins of the Sacramento and San Joaquin rivers to be impounded behind dams or other restraining works. This restricts the output, as not nearly as much gravel can be washed in a given time with a given quantity of water as when the débris

[1] Report of the Director of the Mint on the Production of the Precious Metals, 1894, pages 226 to 229.
[2] Ibid., 1900, page 62.

[3] Tenth Census, Vol. XIII, Report on Precious Metals, page 187.

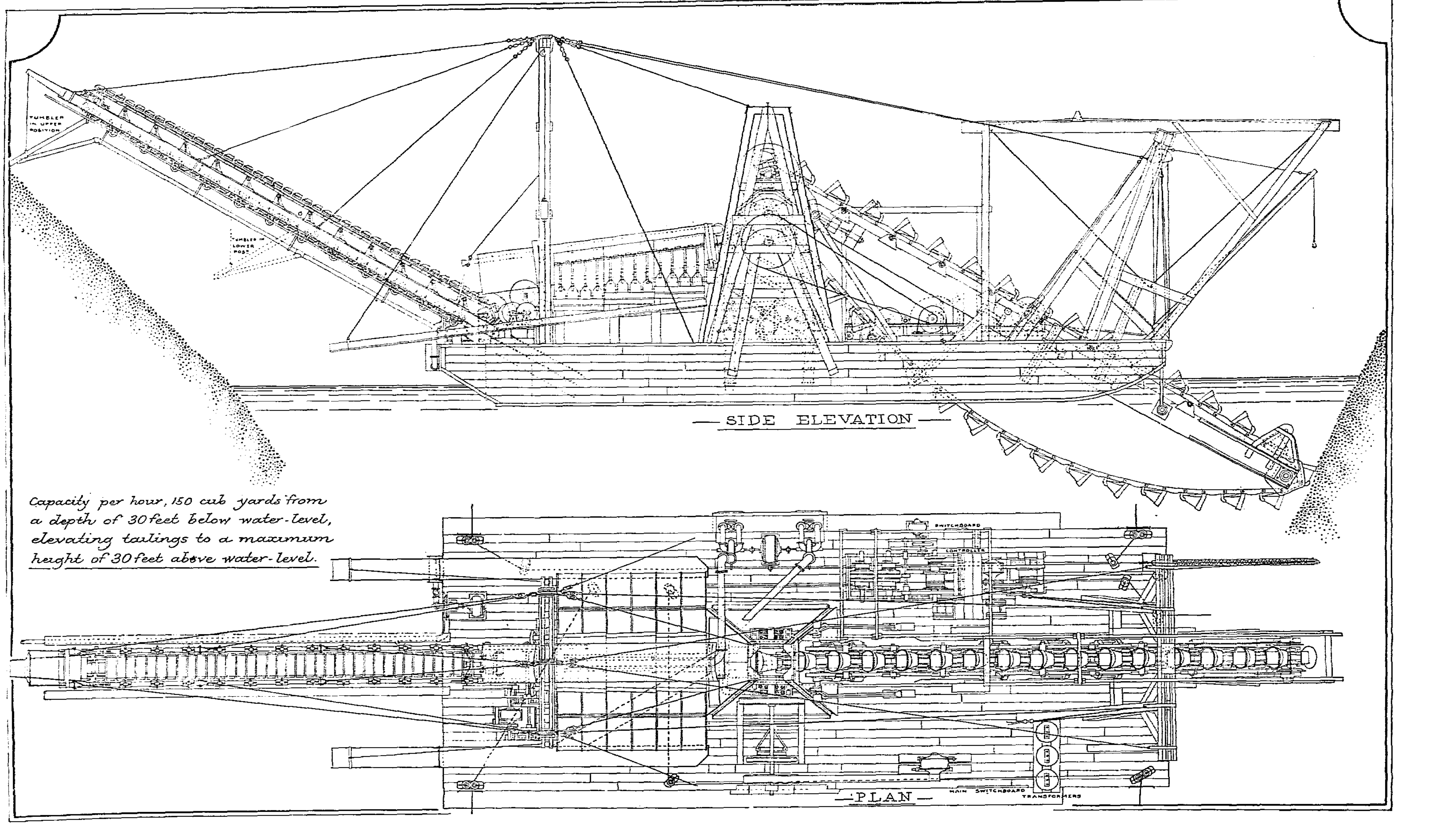


PLATE I.—GOLD DREDGE DRIVEN BY ELECTRIC POWER.

passed away and took care of itself without having to be impounded.

When the first surface diggings were exhausted, attention was turned to deep lying auriferous gravels which are overlaid by a capping of volcanic rock or by a deep stratum of barren gravel. These mines are worked by drifting.

The "drifting" process consists in running long tunnels under the lava-capped divides and tapping the ancient river channels, receiving only the lower and richer stratum of gravel and then washing it, or, if cemented, crushing it under light stamps. In some places shafts 70 or 80 feet deep are sunk, and the lower gravel near bed rock is breasted out, hoisted, and washed. The larger drift mines are usually opened by tunnels.[1]

A quarter of a century ago the gravel was shoveled into hand cars and wheeled out to the mouth of the tunnel.[2] Since that time the larger drift mines in following the gravel channel have continued to extend their tunnels until they are miles in length.

To-day the gravel is removed by trains of cars operated by compressed air or electricity, the power being generated by the water flowing from the tunnels. The tunnels and drifts are lighted by electricity. A material saving in cost is made by the use of these compressed air or electric power plants. The loaded cars run out on the grade, and the power is used for hauling them back to the breasts at or near the foot of the tunnel. The natural drainage of the mines furnishes the power for haulage, lighting, and ventilating.[3]

The latest invention, one which promises to revolutionize the conditions of placer mining, is the dredge. It originated in New Zealand toward the end of the eighties, and after a few years' successful operation in that country was introduced in the United States and is fast gaining ground here. The great advantage of the dredge is that it is not dependent upon a large supply of water, but may be operated miles away from any stream, in the midst of orchard lands. No ditches or reservoirs are necessary, nor need there be a grade or fall for dump. Ground which has lacked suitable fall or water supply may now be mined by means of dredges. The working of these machines is thus described by Mr. Charles G. Yale in a report to the Director of the Mint on gold mining in California:

A pit or hole is dug at any likely point, in which is built or launched a hull or scow, on which the dredging machinery is placed. The ordinary surface water soon floats the dredge, which then commences operations. The great endless-chain buckets elevate the gravel and earth, which pass through "grizzlies" to separate the rocks and stones and earth. The rocks are carried by elevating apparatus far to the rear of the dredge, while the auriferous material passes through the gold-saving appliances, and the tailings or refuse pass out over the stream. The dredge keeps cutting a new basin for itself to float in as it digs away the bank ahead of it. Of course, the orchard soon disappears under this system, but the underlying gold in the gravel is worth far more than the trees and their product.[4]

[1] Report of the Director of the Mint on the Production of the Precious Metals, 1901, pages 90, 91.

[2] Tenth Census, Vol. XIII, Report on Precious Metals, page 203.

[3] Report of the Director of the Mint on the Production of the Precious Metals, 1901, page 91.

[4] Ibid., 1899, page 87.

The drawing on Plate I shows a California gold dredge which is driven by electric power and raises 150 cubic yards per hour from a depth of 30 feet below water level. The cost of such a machine is from $50,000 to $75,000, which places it beyond the reach of the small placer miner. Large tracts of auriferous ground heretofore lying idle have been bought up to be operated by dredging.[5]

Deep mines (See Plates II and III).—Quartz or deep mining developed naturally from alluvial or placer mining. When the deposits in the beds of the streams or higher up the flanks of the hill were exhausted, the miners followed the lines of the mineral yielding gold and finally came to the mother veins. The beginning of quartz mining also belongs to the Spanish and Portuguese period in the history of this continent. At first the method was merely an adaptation of the processes of alluvial mining. The gold deposit was laid bare by an open cut and worked as nearly as possible like a placer mine. The following description of one of these open mines is quoted from an account of a visit made by Mr. Dawson, secretary of the United States legation at Brazil, to the gold mining region of the state of Minas Geraes:

In Brazil these (the veins) are often of friable material, which can easily be pulverized with the aid of running water, and the country rock on either side of the vein is also frequently of the same character. Where such veins were found, we encountered the ancient open mines that are so characteristic of Brazilian gold mining. It is evident that the old miners knew nothing of the underground mining, and, except in rare instances, their excavations are open to the top. These great gullies were made with the assistance of running water brought from considerable distances in canals carried along a high level of the mountain flank. The water was conducted to the point where the lower outcrop of the vein began, and as it flowed, with the aid of a pick and shovel, the ore and surrounding material were cut away. This process was continued backward up the hill until the gully became so deep that the débris was unmanageable. The extent of some of these excavations is enormous. One at São João da Chapada, a few miles south of Diamantina, is 150 feet deep, 1,000 feet wide, and 2,000 feet long.

The mass of material washed down was concentrated in the rudest conceivable manner. Even the use of the sluice was not understood, and in its place the gravel was given its first wash in a "canoa." This is merely a level section of the canal in which the gravel and débris is carried down. The water is allowed to fall into this level space over a lip a few inches high, and a workman stirs with a sort of rake the gravel at that point. Below the "canoa" there is an inclined plane covered with hides laid with the hair up in order to catch the gold that does not sink to the bottom. In addition to the loss of gold inevitable with such a system of washing, the miners labored under the disadvantage of being liable to lose their vein by the falling in of the side rock. And not only did they lose the clue, but it is lost forever. Many of these old mines are undoubtedly still rich, but the veins are so covered up by the débris that their outcrops can not be found and traced. An interesting feature of the larger hillside mines are the "mondeas," rectangular masonry reservoirs, 50 to 80 feet square and 10 to 20 feet deep, made to catch and hold material washed down by the canal until it could be conveniently worked. They were necessary where the amount of water was large. In the few instances where the old miners exploited veins for which no

[5] Report of the Director of the Mint on the Production of the Precious Metals, 1901, pages 91 and 92.

water was available, they simply dug a hole, open to the sky, carrying out the mineral and earth upon the heads of slaves.[1]

Another writer says of their methods of quartz mining:

Quartz mines were only touched where they were found extremely rich, or in a state of decomposition that rendered them easily worked. Explosives were too expensive and difficult to obtain. The mode of working hard quartz was to heat it with fires and then pour cold water upon it, crack it, pry out the pieces, powder it up by hand, and then wash it.[2]

Gold mining in this primitive fashion was possible only with cheap slave labor. "Not the slightest improvement or advance was made as the years went by," says another observer. "The ruins of an abandoned working in Minas Geraes resemble exactly those of the Old World—in Spain, for example, which was to Rome and Carthage what California is to us to-day."[3] The same is true of the silver mines of Peru and Bolivia. "Until a short time ago all ores and all the water had to be carried from the mines on the backs of the workmen in leather bags."[4]

It goes without saying that the absence of mechanical apparatus for hoisting and pumping did not permit of vein mining except at very shallow depths.

In the United States the pioneer state in vein mining was Georgia, where a few deep mines were operated in the first half of the nineteenth century. The first miners naturally followed the methods which were in vogue in the Latin-American countries, whose experience extended over nearly three centuries. It is learned from a recent description that as late as the close of the nineteenth century a specimen of an open mine not very different from its Brazilian prototype was in actual operation in Georgia.

Where saprolite deposits are being worked by open cut, pipe lines are run from the water supply to the reservoirs or to hydraulic giants in the cuts. While the reservoir is being filled from the pumphouse, men are set to work in the open cut, with picks, to dig out the soft auriferous saprolite, and to break up any large masses of quartz that may be encountered, leaving the material where the waters will have free access to it. One of their number then goes up to the reservoir and opens the gate, when the water pours out in torrents down over the loosened saprolite, mixing with it till it forms a thick, slimy mud of the consistency of fresh mortar. This is gradually thinned down by the rushing waters, and is carried, with the angular blocks of quartz and harder saprolite, through the flume to the mill. The water, heavily charged with solid matter, rushes down the flume, through the sluices, and into the ore bin in the mill, where it deposits the coarser material, such as sand and blocks of saprolite and quartz, while the muddy water, containing a large part of the gold, passes through the racks, out of the mill, and into the nearest stream. The material which has been left in the ore bin is fed, by hand, into the stamp mill, and the gold is caught on the amalgamated copper plates, which vary in length from 4 to 12 feet. Short riffle boxes, containing mercury, are placed in connection with these plates, at their lower end, to catch such of the gold as may pass, with the tailings, over the plates; though it is known to be true that gold coated by lumonite ("rusty gold") will not amalgamate, and such of it as is not caught by the riffles must be lost.

One can not repress astonishment that so wasteful a system could have been in use for so long a time, especially as the ores are, for the most part, of low grade, though it is argued in its favor that this method of mining the saprolites carries with it the minimum of expense. While some of the gold, liberated by the disintegration of the auriferous saprolite by the waters, is caught up by the riffles in the sluices, and some finds lodgment in the ore pile in the mill house, still it is said, and is currently believed, that from 25 to 50 per cent of it is lost, being held by the solid matter in the swiftly running waters, eventually passing through the racks of the ore bin and out of the mill house before it is deposited. I am reliably informed that gold passing through the Preacher mill in this way is found all along the bed of the Tanyard branch, from the mill to the creek, a distance of 1 mile.[5]

In the early days of quartz mining in the United States the veins were worked to shallow depths only. In New Mexico about forty years ago powder was practically unknown in mining, and the veins could not be worked for more than 50 feet in depth.[6] Water was another source of trouble. Mines were operated by men of small means, capital was scarce, hand pumps only could be afforded, and when the column of water in the pump became too heavy to be lifted by hand, shafts with a good average grade of ore had to be abandoned. A recent example of this character is cited in the Report of the Geological Survey of Georgia, where but a few years ago a mine was abandoned upon reaching the depth of 300 feet, 30 feet below water level, because the operators had to lift with a hand pump an 80-foot column of water in order to keep the shaft free. At the time work ceased the ore was yielding $25 per ton.[7] The progress in the course of the last half century consisted in the introduction of more powerful hoisting and pumping machinery, in the invention of power drills and more effective explosives, in the construction of extensive tunnels for draining the mines, and lately in the application of electric power.

The evolution of mining methods and machinery is best exemplified by the history of the famous Comstock lode in Nevada. The greatest depth reached after more than twenty years of operation was 3,300 feet. In 1886 work in the lower levels had to be abandoned because of the overpowering flow of water. An instructive description of the powerful pumping plants which were in use at that time is given by Mr. R. K. Colcord, assayer of the United States Mint at Carson City, Nevada:[8]

The pump of the Union shaft works at the north end of the lode. Still there was what is generally known as a direct-acting double line of Cornish pumps with 10-foot stroke, driven by a compound

[1] Report of the Director of the Mint on the Production of the Precious Metals, 1898, page 180.
[2] Ibid., 1894, page 211.
[3] Ibid., 1901, pages 253, 254.
[4] Ibid., 1894, page 52.

[5] A Preliminary Report on a Part of the Gold Deposits in Georgia, by W. S. Yeates, state geologist, pages 315 to 317.
[6] Report of the Director of the Mint on the Production of the Precious Metals, 1885, page 168.
[7] Geological Survey of Georgia, page 353.
[8] Report of the Director of the Mint on the Production of the Precious Metals, 1901, pages 162 to 166.

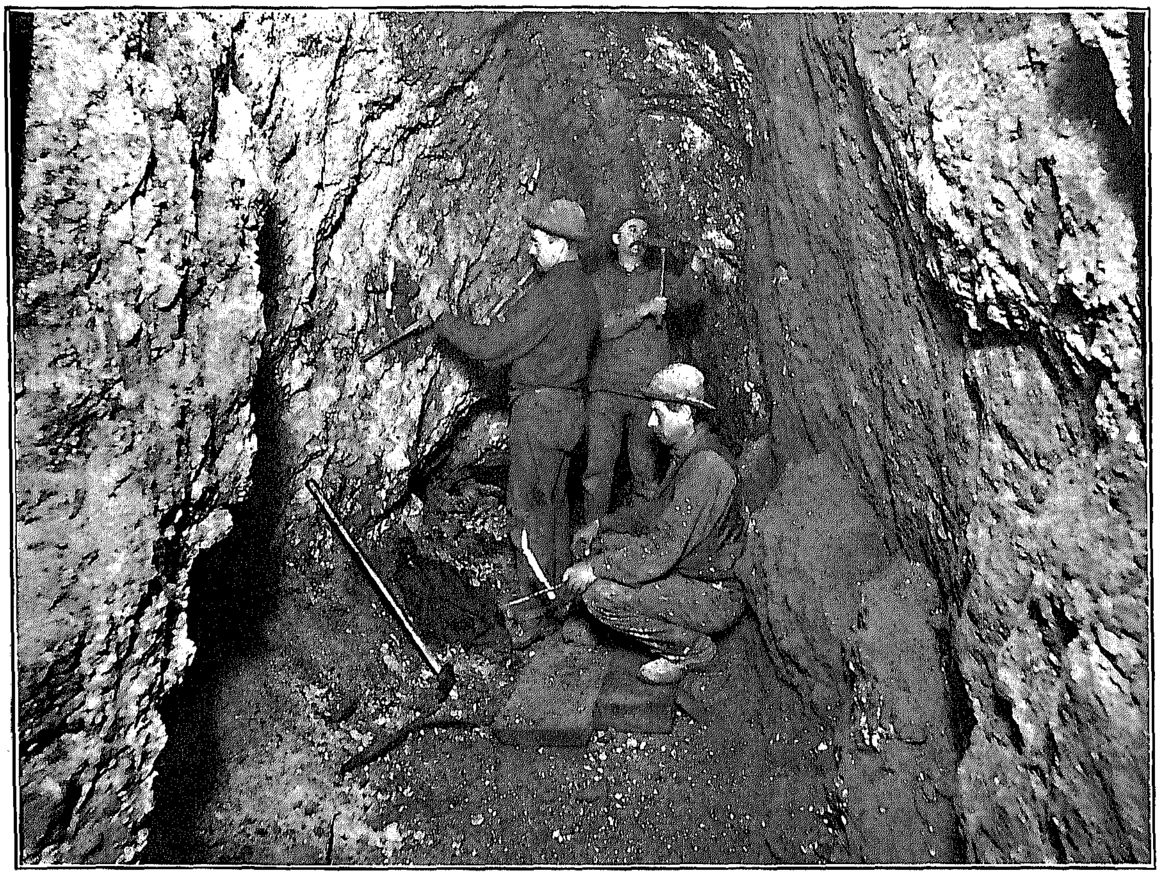


PLATE II.—VEIN IN 1,200-FOOT LEVEL, DALY-JUDGE MINE, PARK CITY, UTAH.

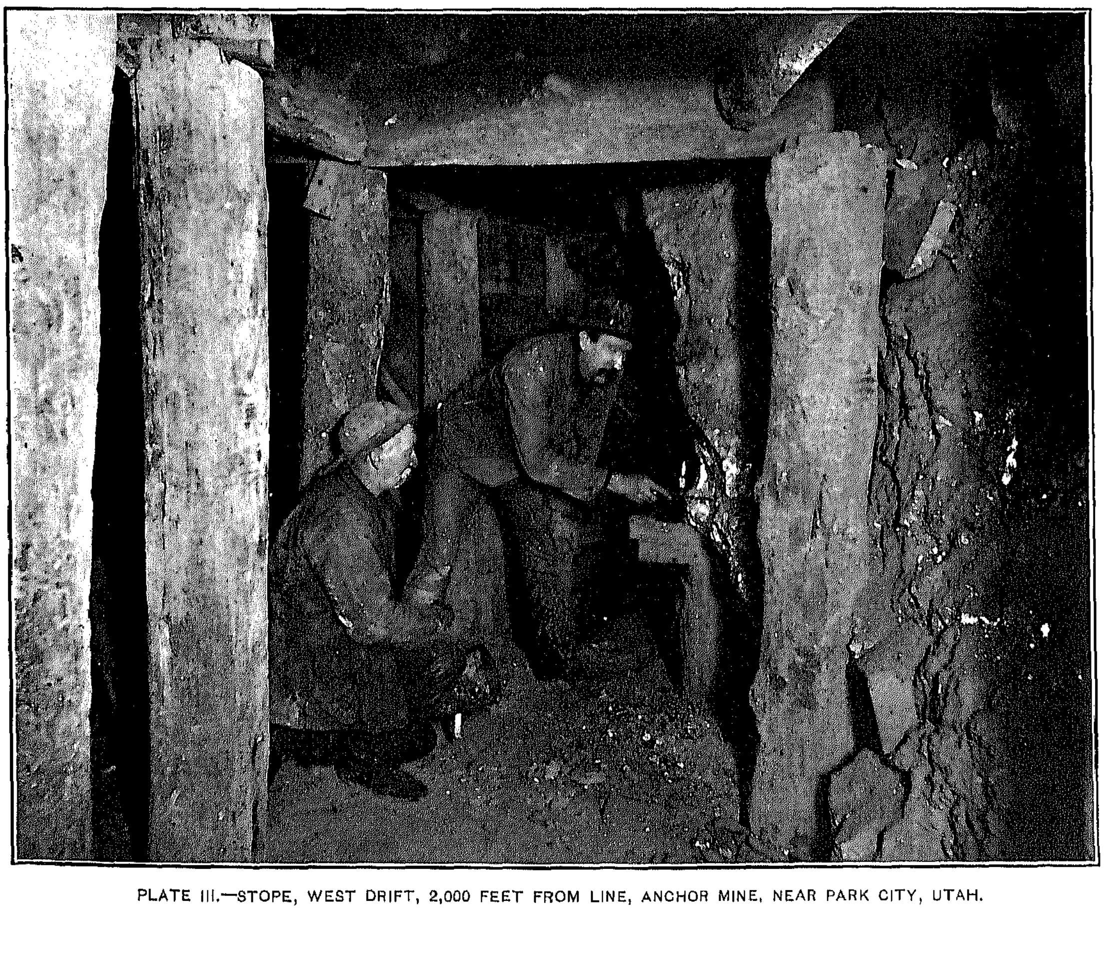


PLATE III.—STOPE, WEST DRIFT, 2,000 FEET FROM LINE, ANCHOR MINE, NEAR PARK CITY, UTAH.

engine within inclined cylinders and inverted walking beam. The initial cylinder is 64 inches in diameter, with 6 foot 9 inch stroke, and the low-pressure cylinder is 100 inches in diameter, with 8 foot 6 inch stroke. The fly wheel is 36 feet in diameter and weighs 208,700 pounds. The wrought-iron walking beam is 22 feet long and weighs 238,610 pounds.

The pump rod is 18 by 18 inch Oregon pine, 2,618 feet in length, and its total weight in motion was 1,620,500 pounds; capacity about 750 gallons per minute to a height of 1,180 feet. This pump was started in 1880 and did good work, but was very expensive in its operation. The whole plant complete cost over $1,000,000.

The Yellow Jacket mine, Gold Hill, had a double line of 14-inch pumps with 10-foot stroke, driven by a horizontal compound engine with double box castings, 64 feet long for the bedplate. The initial cylinder was 31 inches in diameter, with 12-foot stroke, and the low pressure 62 inches in diameter, with 12-foot stroke. The pump rod was 3,055 feet long and weighs, when in motion, 1,510,400 pounds. Its greatest capacity was raising 750 gallons of water 1,516 feet per minute.

The pumps of the combination shaft of the Chollar-Norcross-Savage mining companies, 3,200 feet deep, consisted of a 14-inch Cornish pump and a hydraulic pumping plant, the first on the Comstock. This was operated by waterpower furnished by the Virginia and Gold Hill Water Company and discharged into the Sutro Tunnel. About the time deepest mining was discontinued and the mines allowed to fill and become permanently submerged, which was in October, 1886, this hydraulic system was lifting 2,138 gallons per minute a distance of 1,620 feet to the tunnel level. The total cost of this pumping arrangement was over $1,000,000.

At the date mentioned that hydraulic pump had all the water it could possibly handle. The Hale and Norcross 3,200-foot level had come to a connection with the combination shaft, also the Savage and the Chollar, was drifting south from the shaft on the same level. But the Chollar, drifting toward the already submerged mines of Gold Hill, encountered a constant increase of water—more than the hydraulic pump could manage. The water gained upon the shaftmen, and the result was that as no increase of pump power was feasible all had to submit to the inevitable and allow the hot water to have full submerging sway henceforth.

Recent improvements in electrical engineering and reduction processes have led to the resumption of mining on the levels which had been submerged for many years. Says Mr. Colcord:

The ponderous and powerful hoisting and pumping steam machinery plants of the chief mining companies, originally costing $500,000, $750,000, or more apiece, have become dismantled, and electric, up-to-date machinery of greater power and efficiency is being substituted and installed in their place at comparatively a mere trifle of their original cost. For instance, the electric-hoist plant of the Union Consolidated mine cost only about $10,000; Yellow Jacket and Belcher, $12,000 each; and that at the C and C shaft of the Consolidated California and Virginia, the most productive mine of the lode, $16,000. The cost of power furnished, as per contract with the Truckee River General Electric Company, is $7 per horsepower, based upon a continuous service and a two-minute peak load. In cases of such continuous service this shows an actual saving of 66 per cent. That is, the former rate for steam power was never less than $21 per horsepower.

Technical progress has been facilitated by modern methods of business organization. The pumping association formed for the purpose of pumping the water from the mines of the Leadville basin may be cited by way of illustration.

This association includes nearly all the leasing companies, as well as the owners of territory embraced in the Leadville basin. All mines operating within the association territory bear the cost of pumping in proportion to their output, based on net smelter returns less cost of hauling. By means of counters on these pumps the amount pumped is computed in gallons and charged to the association at the rate of 10 cents per 1,000 gallons. Those mines which pump are credited with the amount of water they have raised. Taking the entire district, investigation shows that the flow of water which must be handled is not less than 15,000,000 gallons a day. Comparing this amount of water with the average daily tonnage of the district for the past year, we find that 28.6 tons of water are raised for every ton of ore raised. Careful estimates of the cost of pumping have been compiled and show that it costs 4 cents to pump each ton of water to the surface. Hence, the cost of pumping referred to the ore makes a charge of $1.14 per ton extracted.[1]

Reduction of ores.—The extraction of the metals from the ore was in the early period not differentiated from mining. The most natural method which suggested itself to the human mind for dealing with the gold bearing rock was to reduce it to the same state in which the alluvial gold deposits were found and to separate the disseminated particles of gold from the pulverized mass by the familiar method of washing. These primitive methods are still practiced in the uplands of Mexico. Mr. Robert Hill, an American engineer, who examined some of the auriferous deposits in the state of Sonora, thus relates his observations in a village some 60 miles distant from a railroad station:

From the adjacent hills the quartz ore was brought in sacks on burros. This was placed upon a flat stone and pulverized with large round bowlders by small boys, this being apparently the first progenitor of the modern stamp mill. The pulverized material was then placed in a primitive arrastra, ground for thirty days by a perambulating burro, and amalgamated. This industry, so the urbane proprietor informed me, had been carried on by himself and ancestors for many generations, and from the ruins of the arrastras in the neighborhood and local tradition there is little doubt that gold has been mined here in a primitive fashion since the first invasion of Sonora by the Spaniards, in 1530, and probably prior to that time by the people who previously inhabited it. From this place onward we found the country inhabited entirely by the peasant class, whose only means of livelihood was to proceed to the hills when in need and procure a little gold with which to purchase the commodities of life.[2]

Amalgamation was the most important discovery inherited by the American miner from his predecessors. Survivals of the most primitive methods of reduction were recorded by the present census of mines and quarries. In a few cases the ore was crushed in ordinary mortars. At one mine in Maryland the ore, after being crushed in a mortar, was smelted in the neighboring blacksmith shop.

A type of mill generally used in the West in the early days of quartz mining was the Mexican arrastra. As late as 1880 arrastras still outnumbered the stamp mills.[3]

The arrastra in its simplest form consists of a circular bed of rock from 6 to 10 feet in diameter, with walls of vertical planks, having

[1] Report of the Director of the Mint on the Production of the Precious Metals, 1900, page 118.
[2] The Engineering and Mining Journal, June 25, 1902.
[3] Tenth Census, Vol. XIII, Report on Precious Metals, pages 282, 283.

an upright pivoted post in the center, from which extend 2 or 4 horizontal arms. Stone drags, weighing usually from 200 to 1,000 pounds each, are attached by ropes or chains to the extremities of the arms, and are slowly drawn around by the rotation of the latter. The depth is usually between 18 and 30 inches. The pavement and drags are of the hardest rock conveniently obtainable. * * * One man per shift can take care of two arrastras. Some waterpower arrastras working on tailings are so arranged that the only attendance needed is in feeding and discharging them, so that practically the labor required is less than the constant work of one man. Continuous arrastras receive no attention other than that demanded for repairs. The smaller arrastras are worked by a single mule or horse. When waterpower is obtainable, a small overshot hurdy-gurdy, or turbine wheel, is employed.[1]

The capacity of an arrastra does not exceed 4 tons per day of twenty-four hours, and usually varies from 1 to 2 tons. A crude arrastra operated by mule power can be built for $150, which places it within the means of miners with but small capital. The owner often does all the work.

Wooden stamp mills of a very crude type were also known to the Spanish-American miners. A quaint specimen of a homemade stamp mill, fairly representative of its Spanish prototype, was seen at work a few years ago in Georgia. The mine and the mill were worked a few months in the year by the owner, with the aid of his aged mother.

The son packed selected ore in a bag on his back to a rude mill a quarter of a mile from the shafts and emptied it into a nail keg. The mother fed the mill with a shingle. Working thus from sunrise to sunset they eked out a living, never making less than $1 a day apiece. The stamp mill has been accepted by all who have seen it as the first of its kind. A 10-foot overshot water wheel, with axis elongated at one side, set in propped posts, constitutes the motor. Three spindles, roughly hewn, are shod with radially arranged and overlapping bands of iron (pieces of a wheel tire) bound by a ring. These are the stamps. The mortar consists of the remnant of the shoe material. Flat iron plugs, bent at the end, are so arranged in the axis that when it revolves these plugs catch, lift, and drop each notched spindle at different intervals. The screen of the mortar chamber is a piece of iron stovepipe rolled out and punctured with nail holes. A combination sluice box does the rest.[2]

This mill was imitated by other miners in the same and neighboring counties. The cost of construction of a first-class mill of this type did not exceed $100. From the wooden mill, by gradual improvement, the present iron stamp mill, with steel shoes and mortars, was developed. The modern stamp milling process is described as follows:

Gold stamp milling is that particular process in which a heavy cylindrical body is made to fall upon the ore in such a manner as to crush it, and thereby facilitate a separation between the gold and the valueless minerals by which the gold is incased. The latter weigh less than the former, and are removed by the aid of water. The gold is then collected through the agency of mercury, with which it readily forms an alloy or amalgam. From this combination it is finally extracted by the distillation or retorting of the mercury. The mechanism of the stamp acts on principles similar to those underlying the crudest devices used by man. It may be likened to a hammer, of which the shoe is the hammer head, the stamp stem is the handle, and the die is the anvil. The ore itself has been compared to a nut struck by a hammer, whose blow has separated the valueless shell (the quartz) from the valuable kernel (the gold). Water covers the die and the ore lying upon it. The blow of the falling stamp not only crushes the ore, but also causes a violent pulsation of the water. That pulsation becomes converted into an irregular splash against the sides of the mortar. The latter has an opening in front, through which the water is discharged, carrying with it the crushed ore. This, called the "pulp," spreads itself over tables placed on an incline, which are lined with a metal, usually copper, having an amalgamated surface, such as will arrest the particles of gold and at the same time permit the grains of quartz and other valueless material to pass over it and out of the mill.[3]

With the further progress of gold mining a point was reached where the stamp mill was found inadequate. After the gold bearing veins had been worked to a certain depth, usually a few hundred feet below the surface, the gold would cease to be "free milling" and, because of the lack of those changes which are due to the penetration of water from the surface, would become "refractory," that is, locked up in union with iron pyrite and other materials, so that it would not amalgamate with quicksilver.[4] Many mines were abandoned when the free milling ores gave out. In Gilpin county, Colo., this condition was met with very early in its mining history, at levels varying from 100 to 200 feet.

The mills which had previously been extracting from 60 per cent to 70 per cent of the gold contents gradually commenced to return only 50 per cent, 40 per cent, and then 30 per cent. None but the richest ore would now pay; the mills swallowed up two-thirds of the yield which should have rewarded the miner's toil; some of the mines were forced to shut down, while others had to confine their development to the narrower, richer portions of the lodes. * * * At this juncture a small smelting establishment was erected in the district, and the metallurgist came to the rescue of the baffled millman.[5]

The problem was not fully solved, however, until the eighties, when the process of concentration was introduced. Only rich ores could bear the expense of shipment to distant smelters. As a result, low-grade refractory ores which could not be treated by amalgamation were thrown away. The new process of concentration, which reduced the volume of ore to be shipped and treated, was tantamount to a discovery of new gold mines.

An illustration of a modern stamp mill, equipped with a concentrator, is shown on Plate IV.

The following description of this process is condensed from the report of the Colorado bureau of mines:

The system of ore dressing known as concentration is one of the most important of all processes applied to the treatment of ores carrying low values in gold, silver, lead, and copper. There is probably no other line of ore dressing so universally used. Notwithstanding the new devices introduced, all are in line with the early and original designs, differing only in the manner of application of principles involved. The theory of concentration is based

[1] Tenth Census, Vol. XIII, Report on Precious Metals, pages 282, 283.

[2] A Preliminary Report on a Part of the Gold Deposits of Georgia, pages 68, 69.

[3] Stamp Milling of Gold Ores, by T. A. Rickard, pages 1, 2.

[4] Report of the Director of the Mint, 1901: "The Future of the Gold Supply," by N. S. Shaler, of Harvard University, from the International Monthly, November, 1901.

[5] Stamp Milling of Gold Ores, pages 12 and 14.

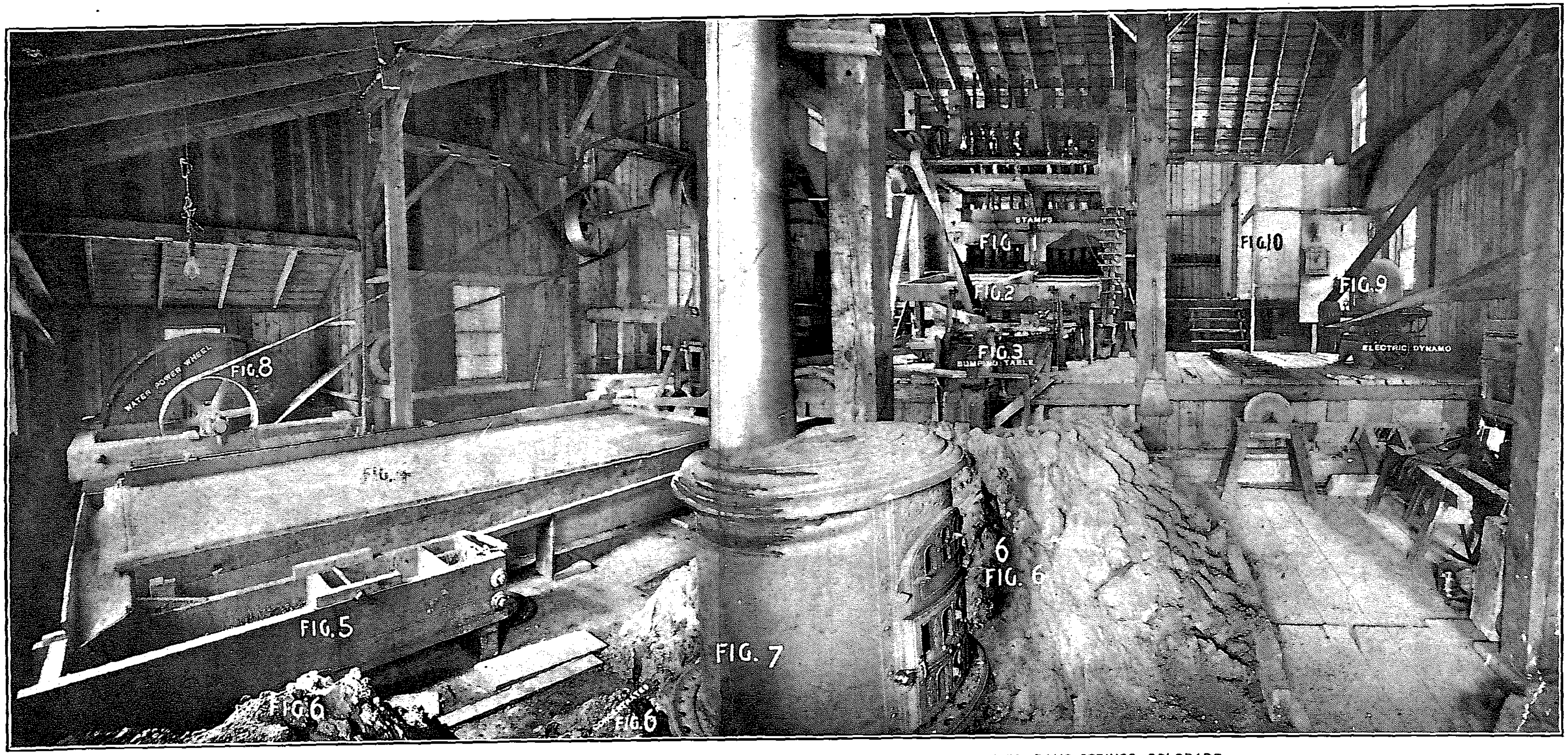


PLATE IV.—INTERIOR OF MILL OF THE UNITED GOLD MINING, MILLING, AND TUNNEL COMPANY, IDAHO SPRINGS, COLORADO.

Fig. 1. Ten-stamp ore crusher. Fig. 2. Amalgamated plates to catch free gold. Fig. 3. Bumping table to catch coarse concentrates. Fig. 4. Wilfley table to catch fine concentrates and slimes. Fig. 5. Concentrating box. Fig. 6. Concentrates piled on the floor. Fig. 7. Heating stove. Fig. 8. Closed-in waterpower wheel (Pelton 4 feet). Fig. 9. Thirty-horsepower electric dynamo, driven by the same waterpower, to operate the machine drills in the mine. Fig. 10. Office and weighing room.

upon the variable specific gravity of the different minerals. Its application is to separate the various metals, collect those having value, and reject the remainder. A large proportion of the concentrates marketed are derived from the stamp-mill tailings. When the value in tailings is in form of pyrite, chalcopyrite, and galena, with gold and silver associated, the ore passes direct from the plates to different patterns of oscillating, or bumping, tables, and the separation made. Where the base minerals occur in comparatively large crystals the stamp battery is often preceded by crusher, rolls, sizing screens, and hartz jigs, the jigs yielding a coarse concentrate, and the tailings from jigs being recrushed in battery over the plates and tables.[1]

The problem of an economical process for the treatment of low-grade ores for many years tempted the inventive spirit of mining men. Many processes were devised only to be rejected by experience. The "process man" became the object of cheap ridicule even in official publications. It was, however, owing to the efforts of one of the multitude of these "process men" that the cyaniding process was invented, which gave to the world the wealth of South African gold. At first the new process was met with distrust by practical mining men, but its demonstrated success overcame the doubts of the skeptics. Immense dumps of low-grade ore and tailings which had been accumulating since the beginning of mining operations were taken up and reduced by the new process.

It is estimated by Professor Munroe that in 1902 gold to the value of $8,000,000 was produced by the cyaniding process in the United States. This represents an addition of 13 per cent to the productivity of deep gold mines.

Improvement in the processes of extracting the metals from the ore is a potent factor in the development of mining. By the old amalgamation process not more than 70 per cent, and usually not more than 60 per cent, of the gold contents of the ore was saved. With the aid of modern processes more than 90 per cent of the assay contents can be recovered.

General industrial conditions.—The development of the railway system with consequent reduction in freight rates has greatly stimulated the growth of gold and silver mining. When mining operations first commenced in Arizona, some mines were 300 miles away from the nearest railroad, and machinery and supplies were brought in by mule teams.[2] Twenty years ago no mine could be worked there which produced ore worth less than $150 per ton.[3] In some mining districts of Colorado, as late as fifteen years ago, before they were reached by railways, all ores were subject to freight charges, varying from $50 to $100 per ton. These conditions are now largely a thing of the past. To-day, all important mining camps are crossed by spurs and switches connecting the principal mines with the main railway line. This means a saving of many dollars per ton on all ores shipped, besides a saving on coal and other mine supplies. The decrease of the average value of the ore per ton has been noted on a preceding page. In the light of present statistics the following quotation from a report published twenty years ago on silver mining in California is instructive:

> Only ores worth from $100 to $200 are sent to mills. Richer ores are sold in San Francisco or elsewhere, while the low-grade ores are dumped. Dumps are covered with a large quantity of ore, the greater portion of which is low grade, averaging from $40 to $60 to the ton.[4]

Silver ores averaging from $40 to $60 to the ton are to-day considered exceptionally rich.

The decline in the average grade of ore mined and treated must not be mistaken for an indication of what the economists call "diminishing returns." The dumping of a portion of the ore after it has been raised from the mine increases the average cost of mining per ton of ore treated. Since it has become possible to treat low-grade ores which formerly had to be thrown away, the returns have increased in proportion to the expense per ton of ore actually raised, there being no additional cost of mining. Thus production has been cheapened.

The combined effect of all these advances in the processes of mining and reduction and in transportation has been the reopening of many mines which were abandoned years ago when the supply of the very rich choice ores had been exhausted. Says Mr. Yale, who has for many years been a close student of mining conditions in California:

> Along the mother lode the best paying mines of to-day, and the deepest, are those which had lain idle for many years, but were intelligently reopened and properly equipped with modern machinery. Capitalists seem to prefer to reopen a mine which had made a record for bullion output in its early history rather than to take the chances on opening and developing an entirely new prospect. Several of the most productive mines at the present day are those which were abandoned twenty or thirty years ago, at a depth of 400 or 500 feet, when it was thought there was nothing worth seeking for further down. On the reopening of these mines, however, systematic deep sinking was carried on, since which time they have been much more profitable than during their early career.[5]

The introduction of improved machinery and reduction methods calls for a large investment of capital. The effect of the technical progress has therefore been the gradual displacement of the small operator working his mine without hired labor on the "grub-stake" plan, and the concentration of gold and silver mining under the management of large companies. The general trend toward production on a large scale has already been noted. The movement toward combination, however, has as yet not reached the gold and silver mines. Small properties have here and there been combined into larger ones; still these small aggregations in no way differ from ordinary incorporated companies and lack the magnitude which is characteristic of a modern industrial combination. In the reduction of ores, on the other hand, combination has made considerable progress.

[1] Report of the State Bureau of Mines of Colorado, 1897, pages 134 and 135.
[2] Report of the Director of the Mint on the Production of the Precious Metals, 1901, page 72.
[3] Ibid., 1884, page 56.
[4] Report of the Director of the Mint on the Production of the Precious Metals, 1884, page 542.
[5] Ibid., 1900, pages 82 and 83.

TABLE 90.—DETAILED SUMMARY,

		United States.	Alabama.	Arizona.	California.	Colorado.	Georgia.
1	Number of mines	2,992	4	74	1,020	772	45
2	Number of operators	2,992	4	74	1,020	772	45
	Character of ownership:						
3	Individual	958	2	16	401	166	17
4	Firm	923	......	15	362	211	11
5	Incorporated company	1,079	2	43	241	389	17
6	Other forms	32	......	......	16	6	......
	Salaried officials, clerks, etc.:						
7	Total number	3,480	7	169	748	1,148	59
8	Total salaries	$5,076,773	$6,710	$283,033	$1,049,846	$1,687,518	$29,508
	General officers—						
9	Number	437	2	22	80	148	1
10	Salaries	$810,555	$1,000	$50,675	$125,568	$280,002	$905
	Superintendents, managers, foremen, surveyors, etc.—						
11	Number	1,725	4	88	418	551	32
12	Salaries	$2,724,092	$5,150	$157,399	$659,123	$891,257	$19,122
	Foremen below ground—						
13	Number	850	1	35	159	275	19
14	Salaries	$1,090,963	$560	$49,562	$180,383	$345,608	$6,708
	Clerks—						
15	Number	468	......	24	91	174	7
16	Salaries	$451,163	......	$25,397	$84,772	$170,651	$2,773
	Wage-earners:						
17	Aggregate average number	36,142	34	1,442	7,989	11,200	334
18	Aggregate wages	$36,077,492	$12,182	$1,498,251	$7,101,003	$11,726,123	$107,718
	Above ground—						
19	Total average number	11,204	12	459	2,675	3,285	187
20	Total wages	$11,233,608	$4,890	$513,076	$2,410,549	$3,556,482	$56,894
	Engineers, firemen, and other mechanics—						
21	Average number	4,515	8	216	986	1,565	47
22	Wages	$5,212,222	$3,990	$285,940	$1,018,277	$1,884,112	$17,402
	Miners—						
23	Average number	1,324	......	23	521	100	107
24	Wages	$1,013,337	......	$22,910	$395,939	$92,081	$30,580
	Boys under 16 years—						
25	Average number	21	......	......	4	1	3
26	Wages	$6,009	......	......	$1,074	$580	$390
	All other wage-earners—						
27	Average number	5,344	4	220	1,164	1,619	30
28	Wages	$5,002,040	$900	$204,226	$995,259	$1,579,709	$8,522
	Below ground—						
29	Total average number	24,938	22	983	5,314	7,915	147
30	Total wages	$24,843,884	$7,292	$985,175	$4,690,454	$8,169,641	$50,824
	Miners—						
31	Average number	18,413	8	636	3,796	6,175	88
32	Wages	$18,737,954	$3,540	$685,344	$3,495,259	$6,340,911	$35,454
	Miners' helpers—						
33	Average number	3,293	7	107	1,013	727	42
34	Wages	$3,004,334	$1,512	$111,906	$799,116	$774,371	$11,236
	Boys under 16 years—						
35	Average number	6	......	......	3	......	......
36	Wages	$2,517	......	......	$1,060	......	......
	All other wage-earners—						
37	Average number	3,226	7	240	502	1,013	17
38	Wages	$3,099,079	$2,240	$187,925	$395,019	$1,054,359	$4,134
	Average number of wage-earners at specified daily rates of pay:						
	Engineers—						
39	$0.75 to $0.99	4	......	......	......	......	......
40	$1.00 to $1.24	26	......	......	......	......	18
41	$1.25 to $1.49	6	......	......	......	......	3
42	$1.50 to $1.74	6	......	......	2	......	1
43	$1.75 to $1.99	2	2	......	......	......	......
44	$2.00 to $2.24	5	......	......	3	......	......
45	$2.50 to $2.74	31	......	......	21	2	1
46	$2.75 to $2.99	19	......	1	11	4	......
47	$3.00 to $3.24	354	......	2	165	126	......
48	$3.25 to $3.49	74	......	2	27	22	......
49	$3.50 to $3.74	337	......	14	57	66	......
50	$3.75 to $3.99	37	......	1	2	14	......
51	$4.00 to $4.24	548	......	52	16	225	......
52	$4.25 and over	79	......	2	7	36	......
	Firemen—						
53	$0.75 to $0.99	4	......	......	......	......	2
54	$1.00 to $1.24	10	2	......	......	......	2
55	$1.50 to $1.74	5	......	......	......	......	......
56	$1.75 to $1.99	4	......	......	2	......	......
57	$2.00 to $2.24	15	......	......	4	6	......
58	$2.25 to $2.49	9	......	......	1	6	......
59	$2.50 to $2.74	72	......	6	32	13	......
60	$2.75 to $2.99	27	......	2	5	13	......
61	$3.00 to $3.24	144	......	3	7	48	......
62	$3.25 to $3.49	5	......	......	......	1	......
63	$3.50 to $3.74	128	......	11	6	63	......
64	$3.75 to $3.99	3	......	......	......	......	......
65	$4.00 to $4.24	34	......	1	2	17	......
66	$4.25 and over	5	......	......	......	......	......
	Machinists, blacksmiths, carpenters, and other mechanics—						
67	$0.75 to $0.79	12	......	......	......	......	4
68	$1.00 to $1.24	12	......	......	......	......	4
69	$1.25 to $1.49	14	......	......	......	4	5
70	$1.50 to $1.74	7	......	......	1	......	1
71	$1.75 to $1.99	11	4	......	......	......	2
72	$2.00 to $2.24	68	......	......	13	40	4
73	$2.25 to $2.49	20	......	......	17	......	......
74	$2.50 to $2.74	185	......	4	91	19	......
75	$2.75 to $2.99	74	......	4	34	20	......
76	$3.00 to $3.24	471	......	10	191	193	......
77	$3.25 to $3.49	109	......	1	42	40	......
78	$3.50 to $3.74	564	......	28	141	164	......
79	$3.75 to $3.99	60	......	4	10	12	......
80	$4.00 to $4.24	737	......	52	58	847	......
81	$4.25 and over	228	......	16	18	64	......

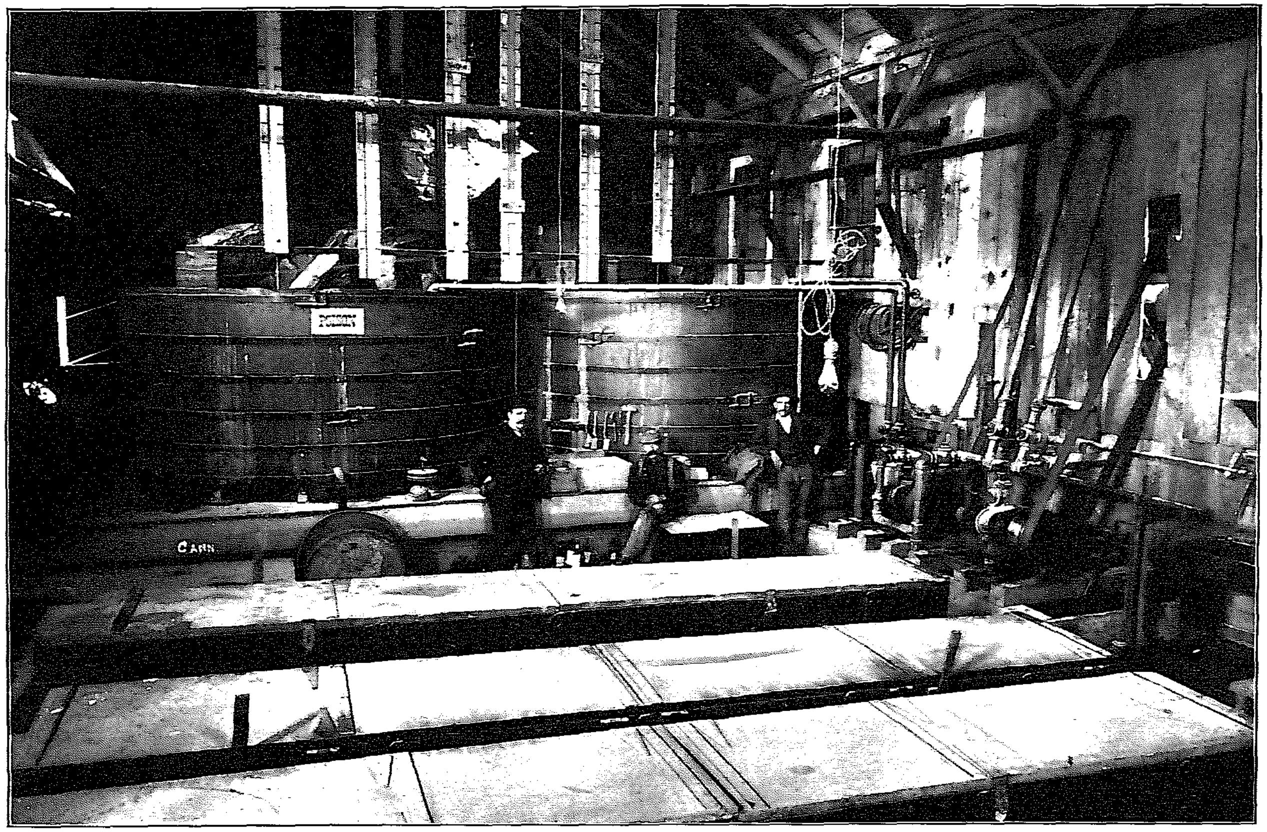


PLATE I.—EUREKA CYANIDE PLANT, NEAR CARSON CITY, NEVADA.

PRODUCING MINES: 1902.

Idaho.	Montana.	Nevada.	New Mexico.	North Carolina.	Oregon.	South Carolina.	South Dakota.	Utah.	Virginia.	Washington.	Wyoming.	All other states.[1]	
258	176	104	91	15	262	3	40	83	5	31	4	5	1
258	176	104	91	15	262	3	40	83	5	31	4	5	2
78	61	35	33	6	118		9	7	2	5	1	1	3
103	50	24	15	3	96	1	7	9	3	11		2	4
75	63	44	39	6	48	2	23	67		15	3	2	5
2	2	1	4				1						6
340	185	136	75	21	110	12	148	261	4	34	4	19	7
$550,548	$318,020	$210,838	$80,390	$18,267	$146,473	$16,750	$222,590	$391,317	$1,815	$36,065	$3,245	$23,840	8
39	24	32	2		10	2	8	59		3		5	9
$98,479	$59,131	$58,224	$6,800		$12,892	$3,000	$16,825	$86,234		$4,920		$5,900	10
154	94	62	43	17	67	7	70	93	3	10	4	8	11
$251,265	$166,158	$101,911	$52,368	$16,380	$92,806	$12,300	$103,852	$167,051	$1,425	$11,580	$3,245	$11,700	12
107	45	20	19	1	19	2	55	69	1	19		4	13
$156,155	$69,748	$31,993	$15,750	$585	$26,955	$950	$86,683	$96,428	$390	$18,065		$4,440	14
40	22	22	11	3	14	1	15	40		2		2	15
$44,649	$22,983	$18,710	$5,472	$1,302	$13,820	$500	$15,230	$41,604		$1,500		$1,800	16
3,382	2,278	1,075	519	203	855	131	2,914	3,349	43	229	25	140	17
$3,698,345	$2,688,052	$1,162,337	$409,779	$66,822	$816,711	$45,500	$3,217,456	$3,176,599	$11,584	$232,058	$24,570	$82,402	18
868	837	372	141	81	436	50	856	848	17	51	8	21	19
$930,418	$976,005	$408,573	$131,252	$28,514	$387,777	$17,400	$911,724	$821,569	$5,186	$53,484	$7,667	$12,148	20
365	283	129	69	28	108	23	319	312	14	28	5	10	21
$437,270	$374,931	$169,899	$75,385	$13,662	$131,602	$8,450	$403,219	$340,735	$4,378	$29,389	$5,221	$8,360	22
128	117	3	31	31	218		32	1	1	2		9	23
$108,814	$122,857	$2,340	$22,944	$8,462	$164,134		$36,555	$1,080	$188	$1,645		$2,808	24
2		2	2	2	2			3					25
$350		$540	$765	$310	$420			$1,580					26
373	437	238	39	20	108	27	505	532	2	21	3	2	27
$383,984	$478,217	$235,794	$32,158	$6,080	$91,621	$8,950	$471,950	$478,174	$620	$22,450	$2,446	$980	28
2,514	1,441	703	378	122	419	81	2,058	2,501	26	178	17	119	29
$2,767,927	$1,712,047	$753,764	$278,527	$38,308	$428,934	$28,100	$2,305,732	$2,355,030	$6,398	$178,574	$16,903	$70,254	30
1,974	1,187	634	295	58	336	28	989	1,919	17	169	15	89	31
$2,181,799	$1,425,801	$696,071	$228,693	$20,653	$347,345	$10,900	$1,173,847	$1,847,831	$4,623	$171,666	$15,393	$52,824	32
334	82	18	54	47	64	20	442	294	9	9		24	33
$352,441	$87,757	$16,756	$31,517	$12,466	$60,989	$6,000	$462,588	$253,796	$1,775	$6,908		$13,200	34
1			1					1					35
$342			$385					$730					36
205	172	51	28	17	19	33	627	287			2	6	37
$233,345	$198,489	$40,937	$17,932	$5,189	$20,600	$11,200	$669,297	$252,673			$1,510	$4,230	38
									4				39
				4		2			2				40
				2		1							41
				2		1							42
													43
		1		1									44
					3			3		1			45
		1	1					1					46
6	1	10	11		4		3	25		1			47
3			3		2			13		1	1		48
69	13	10	5		10		56	35		1	1		49
4	1	2	1		2			6		4			50
53	110	13	3		9		47	16		1		3	51
10	8	12	2		1			1					52
						2							53
				3		3							54
8				1								1	55
				2									56
2			1									2	57
		1						1					58
					1		3	17					59
					2			5					60
3	5	4	2		2		44	26					61
8								1					62
28	14	2	2		1					1			63
3													64
4	8	2											65
1		2						2					66
						6			2				67
				4		1			3				68
				4					1				69
1						3						1	70
				4					1				71
5		1				3			1			1	72
			1	1				1					73
3						1		17					74
		1			4			11					75
11	6	7	7		11		4	29		2			76
3			1		3			19					77
39	32	17	6		29		53	41		13	1		78
1	3		1				4	25					79
95	60	18	14		18		52	16		3	2	2	80
15	22	25	8		6		53	1					81

[1] Includes operators distributed as follows: Arkansas, 1; Maryland, 1; Tennessee, 2; Texas, 1.

TABLE 90.—DETAILED SUMMARY,

		United States.	Alabama.	Arizona.	California.	Colorado.	Georgia.
	Average number of wage-earners at specified daily rates of pay—Cont'd.						
	Miners—						
82	$0.50 to $0.74	10					
83	$0.75 to $0.99	113					72
84	$1.00 to $1.24	156	2		7		61
85	$1.25 to $1.49	119					32
86	$1.50 to $1.74	117		1	31	2	2
87	$1.75 to $1.99	176	6	12	102		28
88	$2.00 to $2.24	257		6	76	39	
89	$2.25 to $2.49	278		6	67	31	
90	$2.50 to $2.74	2,869		6	1,330	800	
91	$2.75 to $2.99	2,238		34	823	635	
92	$3.00 to $3.24	7,200		271	1,647	3,481	
93	$3.25 to $3.49	745		76	59	49	
94	$3.50 to $3.74	4,310		242	87	547	
95	$3.75 to $3.99	199			2	171	
96	$4.00 to $4.24	910		5	84	498	
97	$4.25 and over	40			2	22	
	Miners' helpers—						
98	$0.50 to $0.74	16					1
99	$0.75 to $0.99	49	7				20
100	$1.00 to $1.24	60					21
101	$1.25 to $1.49	23					
102	$1.50 to $1.74	39		1	2		
103	$1.75 to $1.99	99			95	1	
104	$2.00 to $2.24	136			49	1	
105	$2.25 to $2.49	184		2	155		
106	$2.50 to $2.74	810		12	644	35	
107	$2.75 to $2.99	102		13	30	15	
108	$3.00 to $3.24	1,016		54	24	389	
109	$3.25 to $3.49	248		16	6	223	
110	$3.50 to $3.74	502		9	7	58	
111	$3.75 to $3.99	5				5	
112	$4.00 to $4.24	4			1		
	Timbermen and track layers—						
113	$2.00 to $2.24	1					
114	$2.50 to $2.74	57			21	26	
115	$2.75 to $2.99	23		2	8	2	
116	$3.00 to $3.24	177		1	26	101	
117	$3.25 to $3.49	28		12	9	4	
118	$3.50 to $3.74	207		6	2	119	
119	$3.75 to $3.99	9				9	
120	$4.00 to $4.24	31		1		21	
121	$4.25 and over	3				3	
	Boys under 16 years—						
122	Less than $0.50	4			1		1
123	$0.50 to $0.74	6			3		1
124	$0.75 to $0.99	4					1
125	$1.00 to $1.24	1					
126	$1.25 to $1.49	5				1	
127	$1.50 to $1.74	2			1		
128	$2.00 to $2.24	5			2		
	All other wage-earners—						
129	$0.50 to $0.74	22					18
130	$0.75 to $0.99	48	4			1	9
131	$1.00 to $1.24	104	7		6	2	19
132	$1.25 to $1.49	51		1	27		
133	$1.50 to $1.74	107		8	58	3	
134	$1.75 to $1.99	288		90	20	157	1
135	$2.00 to $2.24	693		119	194	219	
136	$2.25 to $2.49	292		20	177	21	
137	$2.50 to $2.74	1,553		50	611	260	
138	$2.75 to $2.99	401		31	95	69	
139	$3.00 to $3.24	2,804		74	243	1,006	
140	$3.25 to $3.49	405		10	38	201	
141	$3.50 to $3.74	825		23	88	231	
142	$3.75 to $3.99	32			16	14	
143	$4.00 to $4.24	290		11	20	136	
144	$4.25 and over	119		1	7	27	
	Average number of wage-earners employed during each month:						
	Men 16 years and over—						
145	January	34,678	32	1,362	7,589	11,168	338
146	February	34,925	34	1,368	7,765	11,197	360
147	March	34,810	34	1,274	8,019	10,844	331
148	April	35,955	34	1,467	8,332	10,959	329
149	May	37,164	32	1,530	8,387	11,394	339
150	June	37,309	34	1,507	8,176	11,678	302
151	July	37,104	34	1,415	7,918	11,573	325
152	August	37,140	36	1,450	7,993	11,428	353
153	September	36,733	37	1,425	7,797	11,312	363
154	October	36,756	38	1,442	8,009	11,370	285
155	November	36,126	32	1,493	8,002	11,086	345
156	December	34,680	31	1,571	7,797	10,384	302
	Boys under 16 years—						
157	January	27			7	1	3
158	February	27			7	1	3
159	March	27			7	1	3
160	April	31			9	1	7
161	May	28			9	1	2
162	June	24			7	1	2
163	July	26			7	1	4
164	August	26			7	1	4
165	September	24			7	1	2
166	October	29			7	1	3
167	November	28			5	1	2
168	December	27			5	1	1
	Contract work:						
169	Amount paid	$626,090	$1,200	$37,605	$47,066	$360,707	$1,030
170	Number of employees	980	2	58	145	473	4

PRODUCING MINES: 1902—Continued.

Idaho.	Montana.	Nevada.	New Mexico.	North Carolina.	Oregon.	South Carolina.	South Dakota.	Utah.	Virginia.	Washington.	Wyoming.	All other states.	
...	...	...	...	10	...	...	...	...	...	...	...	...	82
...	...	...	...	35	...	...	...	...	6	...	...	...	83
12	...	...	24	17	...	8	...	...	12	...	...	13	84
...	...	...	1	10	...	20	...	...	...	...	...	56	85
1	...	43	17	11	8	...	...	...	...	...	...	1	86
8	...	...	4	6	10	...	...	...	...	...	...	...	87
6	...	...	53	...	70	...	1	4	...	2	...	...	88
5	...	...	11	...	11	...	...	147	...	...	...	...	89
14	...	12	65	...	108	...	39	485	...	2	...	8	90
20	...	66	23	...	47	...	...	590	...	...	...	...	91
439	75	217	120	...	207	...	32	593	...	87	11	20	92
490	...	6	...	...	21	...	...	42	...	2	...	...	93
1,083	1,172	46	6	...	66	...	937	49	...	71	4	...	94
3	22	...	...	...	...	...	...	1	...	...	...	...	95
17	28	243	2	...	6	...	12	8	...	7	...	...	96
4	7	4	...	...	...	...	...	1	...	...	...	...	97
...	...	...	...	10	...	...	...	...	5	...	...	...	98
...	...	...	...	18	...	...	...	...	4	...	...	...	99
...	...	...	...	19	...	20	...	...	...	...	...	...	100
...	...	...	2	...	...	...	...	...	...	...	...	21	101
...	...	...	33	...	...	...	...	...	...	...	...	3	102
...	...	...	...	...	...	...	...	3	...	...	...	...	103
4	...	4	5	...	2	...	...	71	...	...	...	...	104
...	...	...	...	...	16	...	...	11	...	...	...	...	105
4	...	...	12	...	3	...	...	91	...	9	...	...	106
...	...	...	...	...	13	...	...	31	...	...	...	...	107
304	62	11	2	...	30	...	53	87	...	...	...	...	108
3	...	...	...	...	...	...	...	...	...	...	...	...	109
19	20	...	...	...	...	...	389	...	...	...	...	...	110
...	...	...	...	...	...	...	...	...	...	...	...	...	111
...	...	3	...	...	...	...	...	...	...	...	...	...	112
...	...	...	...	...	...	...	...	1	...	...	...	...	113
3	...	...	...	...	...	...	...	7	...	...	...	...	114
...	...	...	...	...	...	...	...	11	...	...	...	...	115
27	5	...	...	...	...	...	11	1	...	...	...	5	116
2	...	...	...	...	...	...	...	1	...	...	...	...	117
54	12	...	1	...	3	...	4	6	...	...	...	...	118
...	...	...	...	...	...	...	...	...	...	...	...	...	119
8	1	...	...	...	...	...	...	...	...	...	...	...	120
...	...	...	...	...	...	...	...	...	...	...	...	...	121
1	...	...	...	...	...	...	...	1	...	...	...	...	122
...	...	...	...	2	...	...	...	...	...	...	...	...	123
1	...	1	...	...	1	...	...	...	...	...	...	...	124
1	...	...	...	...	...	...	...	...	...	...	...	...	125
...	...	...	3	...	1	...	...	...	...	...	...	...	126
...	...	1	...	...	...	...	...	...	...	...	...	...	127
...	...	...	...	...	...	...	...	3	...	...	...	...	128
...	...	...	...	4	...	...	...	...	...	...	...	...	129
2	...	...	...	11	...	20	...	...	1	...	...	...	130
9	1	...	1	19	...	33	...	5	1	...	...	1	131
10	...	...	2	...	2	7	...	2	...	...	...	...	132
2	...	20	2	...	4	...	9	...	...	1	...	...	133
2	...	13	2	...	...	...	...	2	...	...	...	1	134
6	2	3	24	3	47	...	16	59	...	1	...	...	135
3	...	...	...	...	3	...	1	67	...	...	...	...	136
18	18	9	15	...	21	...	175	371	...	1	3	1	137
24	...	7	...	...	25	...	3	146	...	1	...	...	138
126	259	179	11	...	1	...	793	109	...	3	...	...	139
93	22	6	...	...	10	...	5	20	...	...	...	...	140
132	218	16	6	...	5	...	80	11	...	13	2	...	141
...	1	...	...	...	...	...	1	...	...	...	...	...	142
53	47	15	1	...	3	...	3	...	...	1	...	...	143
4	23	21	2	...	3	...	31	...	...	...	...	...	144
3,072	2,044	900	480	129	742	131	2,748	3,547	24	188	22	162	145
3,113	2,023	892	501	132	751	131	2,757	3,474	33	236	3	155	146
3,259	2,057	941	483	138	819	131	2,762	3,295	40	216	19	148	147
3,424	2,194	1,061	445	198	894	131	2,868	3,177	42	234	19	147	148
3,516	2,337	1,166	567	212	918	131	2,908	3,255	56	242	19	155	149
3,561	2,456	1,183	512	228	968	131	2,927	3,222	49	207	25	148	150
3,581	2,545	1,180	549	224	955	131	2,930	3,313	47	229	24	131	151
3,543	2,510	1,160	579	231	915	131	2,955	3,419	53	219	34	136	152
3,530	2,417	1,138	544	240	882	131	2,988	3,477	44	236	33	139	153
3,474	2,354	1,113	572	237	826	131	3,057	3,398	38	247	33	132	154
3,347	2,252	1,104	481	232	821	131	3,038	3,302	43	264	33	120	155
3,128	2,147	1,038	479	211	750	131	3,030	3,261	47	230	36	107	156
1	...	3	3	2	3	...	...	4	...	...	...	...	157
1	...	3	3	2	3	...	...	4	...	...	...	...	158
1	...	3	3	2	3	...	...	4	...	...	...	...	159
1	...	3	3	2	1	...	...	4	...	...	...	...	160
4	...	1	3	2	2	...	...	4	...	...	...	...	161
4	...	1	3	2	...	...	...	4	...	...	...	...	162
4	...	1	3	2	...	...	...	4	...	...	...	...	163
4	...	1	3	2	...	...	...	4	...	...	...	...	164
4	...	1	3	2	...	...	...	4	...	...	...	...	165
4	...	1	3	2	4	...	...	4	...	...	...	...	166
4	...	3	3	2	4	...	...	4	...	...	...	...	167
4	...	3	3	2	4	...	...	4	...	...	...	...	168
$41,642	$19,161	$7,944	$32,345	...	$19,197	...	...	$28,493	...	$29,400	$300	...	169
38	26	13	61	...	55	...	...	77	...	27	1	...	170

TABLE 90.—DETAILED SUMMARY,

		United States.	Alabama.	Arizona.	California.	Colorado.	Georgia.
	Miscellaneous expenses:						
171	Total	$5,357,529	$824	$114,046	$967,755	$2,156,217	$9,684
172	Royalties and rent of mine and mining plant	$1,423,399		$2,888	$403,990	$715,309	$3,486
173	Rent of offices, taxes, insurance, interest, and other sundries	$3,934,130	$824	$111,158	$563,765	$1,440,908	$6,198
174	Cost of supplies and materials	$16,699,768	$5,216	$873,091	$2,966,102	$5,603,452	$33,123
175	Value of product	$82,482,052	$1,057	$2,764,677	$15,473,091	$29,655,974	$149,150
	Power:						
176	Total horsepower	195,805	160	5,416	49,582	67,252	3,462
	Owned—						
	Engines—						
	Steam—						
177	Number	1,925	4	100	368	678	53
178	Horsepower	122,354	160	5,086	16,858	48,898	1,403
	Gas or gasoline—						
179	Number	198		16	62	46	
180	Horsepower	4,060		166	957	629	
	Water wheels—						
181	Number	788		1	518	76	14
182	Horsepower	43,936		9	21,517	7,382	2,059
	Other power—						
183	Number	156		2	20	82	
184	Horsepower	8,003		155	1,378	3,447	
	Rented—						
185	Electric, horsepower	14,469			6,880	6,707	
186	Other power, horsepower	2,983			1,992	189	
	Electric motors owned—						
187	Number	750	1	8	265	285	1
188	Horsepower	32,003	12	107	12,081	10,305	100
189	Supplied to other establishments, horsepower	323			100	223	

PRODUCING MINES: 1902—Continued.

Idaho.	Montana.	Nevada.	New Mexico.	North Carolina.	Oregon.	South Carolina.	South Dakota.	Utah.	Virginia.	Washington.	Wyoming.	All other states.	
$614,670	$310,145	$172,206	$34,110	$10,238	$114,402	$4,440	$240,112	$570,250	$444	$23,651	$160	$14,175	171
$28,047	$102,168	$49,652	$13,127	$415	$58,292	$70	$6,406	$23,243	$370	$14,876	...	$1,060	172
$586,623	$207,977	$122,554	$20,983	$9,823	$56,110	$4,370	$233,706	$547,007	$74	$8,775	$160	$13,115	173
$1,605,696	$1,069,300	$599,928	$256,816	$26,490	$299,705	$20,860	$1,936,617	$1,312,176	$4,011	$55,668	$11,139	$20,378	174
$8,177,267	$4,688,536	$3,409,348	$677,168	$71,287	$1,851,853	$138,863	$6,464,258	$8,500,904	$2,723	$338,351	$4,923	$112,622	175
19,115	12,306	4,429	4,000	815	2,949	450	13,329	10,927	92	946	360	215	176
144	183	48	66	26	54	9	76	85	4	17	5	5	177
9,533	9,323	2,883	3,161	815	1,713	450	11,896	8,811	92	747	360	165	178
23	4	17	17	...	7	...	1	3	...	2	...	...	179
1,382	29	342	278	...	115	...	8	120	...	34	...	...	180
88	22	20	6	...	30	...	...	11	...	2	...	...	181
7,553	1,602	1,117	500	...	1,091	...	...	1,066	...	40	...	...	182
10	9	1	3	...	1	...	10	15	...	2	...	1	183
472	402	40	61	...	30	...	1,425	418	...	125	...	50	184
175	150	46	...	...	...	...	...	511	...	...	...	...	185
...	800	1	...	...	...	...	...	1	...	...	...	...	186
39	44	27	13	...	14	1	4	47	...	1	...	...	187
2,119	2,152	1,107	467	...	666	35	70	2,752	...	30	...	...	188
...	...	...	...	...	...	...	...	...	...	...	...	...	189

TABLE 91.—DETAILED SUMMARY, MINES REPORTING

		United States.	Alabama.	Arizona.	California.	Colorado.	Georgia.
1	Number of mines	3,252	3	380	389	955	8
2	Number of operators	3,252	3	380	389	955	8
	Character of ownership:						
3	Individual	683	2	74	111	237	3
4	Firm	849		95	131	282	3
5	Incorporated company	1,695	1	207	146	433	2
6	Other form	25		4	1	3	
	Salaried officials, clerks, etc.:						
7	Total number	2,284	4	385	259	449	6
8	Total salaries	$2,335,470	$3,100	$458,372	$264,575	$434,888	$8,568
	General officers—						
9	Number	302		32	22	64	3
10	Salaries	$242,989		$44,396	$12,995	$42,641	$4,800
	Superintendents, managers, foremen, surveyors, etc.—						
11	Number	1,307	3	253	167	271	2
12	Salaries	$1,523,627	$2,200	$333,944	$188,552	$299,155	$3,600
	Foremen below ground—						
13	Number	430		38	41	77	1
14	Salaries	$410,185		$43,611	$36,698	$71,034	$168
	Clerks—						
15	Number	245	1	62	29	37	
16	Salaries	$158,669	$900	$36,421	$26,330	$22,058	
	Wage-earners:						
17	Aggregate average number	11,763	7	2,243	1,447	2,303	29
18	Aggregate wages	$11,580,684	$2,644	$2,326,885	$1,311,152	$2,314,208	$11,552
	Above ground—						
19	Total average number	2,845	6	604	405	488	9
20	Total wages	$2,782,876	$2,332	$637,741	$359,718	$525,254	$3,563
	Engineers, firemen, and other mechanics—						
21	Average number	1,572	2	308	189	350	3
22	Wages	$1,766,784	$960	$389,446	$190,459	$396,198	$1,200
	Miners—						
23	Average number	312	1	53	75	29	
24	Wages	$235,955	$463	$40,545	$62,341	$25,138	
	Boys under 16 years—						
25	Average number	5		2			
26	Wages	$1,100		$480			
	All other wage-earners—						
27	Average number	956	3	241	141	109	6
28	Wages	$779,037	$909	$207,270	$106,918	$103,918	$2,363
	Below ground—						
29	Total average number	8,918	1	1,639	1,042	1,815	20
30	Total wages	$8,797,808	$312	$1,689,144	$951,434	$1,788,954	$7,989
	Miners—						
31	Average number	8,019		1,506	909	1,662	20
32	Wages	$8,057,301		$1,567,580	$846,810	$1,634,154	$7,989
	Miners' helpers—						
33	Average number	571		67	79	61	
34	Wages	$456,292		$63,475	$59,700	$63,256	
	Boys under 16 years—						
35	Average number	1					
36	Wages	$450					
	All other wage-earners—						
37	Average number	327	1	66	54	92	
38	Wages	$283,765	$312	$58,089	$44,924	$91,544	
	Average number of wage-earners at specified daily rates of pay:						
	Engineers—						
39	$0.75 to $0.99	3					
40	$1.00 to $1.24	4	1				
41	$1.25 to $1.49	9					2
42	$1.50 to $1.74	8			1		
43	$1.75 to $1.99	1					
44	$2.00 to $2.24	3			1		
45	$2.25 to $2.49	2			1		
46	$2.50 to $2.74	20		3	4		
47	$2.75 to $2.99	9		1	6		
48	$3.00 to $3.24	106		4	39	33	
49	$3.25 to $3.49	20		2		11	
50	$3.50 to $3.74	141		15	11	27	
51	$3.75 to $3.99	8				2	
52	$4.00 to $4.24	214		78	1	73	
53	$4.25 and over	58		20	1	8	
	Firemen—						
54	$1.00 to $1.24	9					
55	$1.25 to $1.49	1					
56	$1.75 to $1.99	1					
57	$2.00 to $2.24	4			1		
58	$2.50 to $2.74	5				1	
59	$2.75 to $2.99	1					
60	$3.00 to $3.24	25			1	5	
61	$3.50 to $3.74	30		3	1	9	
62	$4.00 to $4.24	12		4		1	
	Machinists, blacksmiths, carpenters, and other mechanics—						
63	$0.75 to $0.99	1					
64	$1.00 to $1.24	7				1	
65	$1.25 to $1.49	22					
66	$1.50 to $1.74	9					1
67	$1.75 to $1.99	2					
68	$2.00 to $2.24	12	1	4			
69	$2.25 to $2.49	3		2			
70	$2.50 to $2.74	26			15	3	
71	$2.75 to $2.99	7			3	1	
72	$3.00 to $3.24	211		10	56	81	
73	$3.25 to $3.49	27		2	6	6	
74	$3.50 to $3.74	227		34	26	21	
75	$3.75 to $3.99	13		1	4	3	
76	$4.00 to $4.24	261		100	10	55	
77	$4.25 and over	55		25	1	9	

DEVELOPMENT WORK WITHOUT PRODUCTION: 1902.

Idaho.	Montana.	Nevada.	New Mexico.	North Carolina.	Oregon.	South Dakota.	Utah.	Virginia.	Washington.	Wyoming.	All other states.[1]	
325	126	82	156	28	187	114	266	4	143	83	3	1
325	126	82	156	28	187	114	266	4	143	83	3	2
64	30	7	49	11	36	13	28		12	5	1	3
100	37	12	25	7	51	21	47		25	13		4
158	59	61	73	10	100	80	188	4	106	65	2	5
3		2	9				3					6
180	73	142	105	41	129	99	210	8	119	75		7
$164,560	$80,099	$181,172	$88,921	$32,905	$149,674	$114,956	$160,694	$4,535	$110,217	$78,234		8
28	22	23	9	2	7	18	49	1	9	13		9
$16,913	$20,600	$24,415	$6,475	$686	$7,710	$13,174	$20,674	$480	$7,400	$19,680		10
91	36	58	65	27	89	43	95	5	62	40		11
$99,944	$45,057	$86,607	$65,132	$23,673	$113,003	$64,635	$89,311	$3,355	$62,684	$42,775		12
47	9	37	16	8	25	33	48	2	36	12		13
$37,405	$11,407	$49,160	$9,507	$5,116	$25,016	$34,694	$42,356	$700	$33,059	$10,254		14
14	6	24	15	4	8	5	18		12	10		15
$10,298	$3,035	$20,990	$7,807	$3,480	$3,945	$2,453	$8,853		$7,074	$5,525		16
852	481	574	356	343	802	522	936	51	495	304	18	17
$897,412	$552,700	$656,169	$269,996	$102,131	$776,607	$581,163	$903,247	$17,964	$537,478	$311,881	$7,495	18
227	71	122	64	131	206	132	145	19	104	102	10	19
$216,635	$83,820	$155,869	$52,621	$38,443	$181,995	$147,506	$151,306	$7,168	$108,022	$106,788	$4,095	20
85	57	82	39	56	78	87	118	7	58	54	4	21
$96,026	$71,021	$115,237	$34,997	$21,387	$88,202	$103,160	$126,989	$2,550	$67,805	$59,117	$2,030	22
68		3	4	28	38	3	1		9			23
$52,145		$2,923	$2,818	$7,261	$31,168	$3,255	$450		$7,448			24
		1		1				1				25
		$365		$75				$180				26
74	14	36	21	46	90	42	31	11	37	48	6	27
$68,464	$12,799	$37,344	$14,806	$9,720	$62,625	$41,091	$23,867	$4,438	$32,769	$47,671	$2,065	28
625	410	452	292	212	596	390	791	32	391	202	8	29
$680,777	$468,880	$500,300	$217,375	$63,088	$594,612	$433,657	$751,941	$10,796	$429,456	$205,093	$3,400	30
572	392	420	252	110	503	360	724	31	367	183	8	31
$626,151	$451,392	$467,442	$194,869	$36,989	$515,899	$405,747	$698,351	$10,444	$408 891	$186,193	$3,400	32
37	8	25	33	90	67	21	54		16	13		33
$37,595	$8,388	$27,073	$18,846	$23,809	$60,612	$19,930	$47,683		$13,875	$12,600		34
			1									35
			$450									36
16	10	7	6	12	26	9	13	1	8	6		37
$17,031	$9,100	$5,785	$8,210	$2,890	$18,101	$7,980	$10,957	$352	$7,190	$6,300		38
				3								39
				3								40
				5				2				41
				1				1				42
				1								43
			1							1		44
					1							45
			4		5				1	3		46
							1		1			47
2		1	5			8	12		1		1	48
						1	5			1		49
9		14	5		6	21	21		10	2		50
							2			4		51
14	17	6			4	4	7		8	2		52
4	5	12			1	2	2		1	2		53
				9								54
											1	55
					1							56
			2		1							57
			2			1	1					58
			1									59
3		4				1	6			5		60
	4	2	1				4		4	2		61
	4	1							1	1		62
				1								63
				5				1				64
1				18				1			2	65
			1	6				1				66
				2								67
			2	1	2		1	1				68
				1								69
1		1	2		4							70
					1		1		1			71
14		6	4		10	3	17		4	6		72
			2		4	1	5			1		73
17	6	18	5		23	36	16		11	14		74
					1		1		1	2		75
15	17	9	1		13	9	11		13	8		76
5	4	8	1		1				1			77

[1] Includes operators distributed as follows: Arkansas, 1; Maryland, 1; New Jersey, 1.

TABLE 91.—DETAILED SUMMARY, MINES REPORTING

		United States.	Alabama.	Arizona.	California.	Colorado.	Georgia.
	Average number of wage-earners at specified daily rates of pay—Cont'd.						
	Miners—						
78	$0.50 to $0.74	1					1
79	$0.75 to $0.99	59					1
80	$1.00 to $1.24	86	1				8
81	$1.25 to $1.49	64		11	2		10
82	$1.50 to $1.74	132		94	5		
83	$1.75 to $1.99	74		40	9		
84	$2.00 to $2.24	182		77	16	12	
85	$2.25 to $2.49	59			10	13	
86	$2.50 to $2.74	764		69	201	171	
87	$2.75 to $2.99	591		5	248	152	
88	$3.00 to $3.24	2,901		290	411	956	
89	$3.25 to $3.49	236		40	4	46	
90	$3.50 to $3.74	2,611		814	61	205	
91	$3.75 to $3.99	100		13	5	33	
92	$4.00 to $4.24	448		103	12	86	
93	$4.25 and over	23		3		14	
	Miners' helpers—						
94	$0.50 to $0.74	9					
95	$0.75 to $0.99	63					
96	$1.00 to $1.24	18					
97	$1.25 to $1.49	5					
98	$1.50 to $1.74	14		1	1		
99	$1.75 to $1.99	4		1		2	
100	$2.00 to $2.24	44		1	10		
101	$2.25 to $2.49	26			20	2	
102	$2.50 to $2.74	106		4	36	9	
103	$2.75 to $2.99	40		1	6	6	
104	$3.00 to $3.24	172		44	6	23	
105	$3.25 to $3.49	11		10			
106	$3.50 to $3.74	52		5		12	
107	$4.00 to $4.24	7				7	
	Timbermen and track layers—						
108	$1.50 to $1.74	4					
109	$2.00 to $2.24	1				1	
110	$2.25 to $2.49	2				2	
111	$2.50 to $2.74	9			3	2	
112	$2.75 to $2.99	3			1	2	
113	$3.00 to $3.24	14			1	6	
114	$3.25 to $3.49	1					
115	$3.50 to $3.74	3				2	
116	$4.00 to $4.24	1				1	
	Boys under 16 years—						
117	Less than $0.50	1					
118	$0.50 to $0.74	1					
119	$0.75 to $0.99	1		1			
120	$1.00 to $1.24	2		1			
121	$1.50 to $1.74	1					
	All other wage-earners—						
122	Less than $0.50	11					
123	$0.50 to $0.74	7			1	1	
124	$0.75 to $0.99	36			1		
125	$1.00 to $1.24	49	4	6	3	5	2
126	$1.25 to $1.49	32		15	1	1	4
127	$1.50 to $1.74	60		30	3	10	
128	$1.75 to $1.99	56		5	2		
129	$2.00 to $2.24	110		34	40	9	
130	$2.25 to $2.49	53		5	24	2	
131	$2.50 to $2.74	184		34	68	16	
132	$2.75 to $2.99	68		21	20	16	
133	$3.00 to $3.24	399		111	18	81	
134	$3.25 to $3.49	13		2	2	3	
135	$3.50 to $3.74	106		25	1	17	
136	$3.75 to $3.99	2			1	1	
137	$4.00 to $4.24	47		11	5	21	
138	$4.25 and over	12		8		2	
	Average number of wage-earners employed during each month:						
	Men 16 years and over—						
139	January	9,857	1	1,878	1,069	1,986	25
140	February	9,937	1	1,934	1,103	2,023	25
141	March	10,165		2,052	1,209	2,010	26
142	April	10,394	8	2,092	1,278	1,977	26
143	May	10,957	8	2,176	1,343	2,073	33
144	June	11,690	8	2,166	1,420	2,276	33
145	July	12,335	8	2,269	1,480	2,453	33
146	August	12,636	10	2,217	1,504	2,569	33
147	September	13,231	10	2,250	1,600	2,684	27
148	October	13,384	10	2,476	1,696	2,623	31
149	November	13,482	10	2,711	1,828	2,593	28
150	December	13,016	10	2,671	1,839	2,369	28
	Boys under 16 years—						
151	January	4		1			
152	February	4		1			
153	March	6		3			
154	April	6		3			
155	May	7		3			
156	June	5		1			
157	July	5		1			
158	August	5		1			
159	September	6		1			
160	October	8		3			
161	November	8		3			
162	December	8		3			
	Contract work:						
163	Amount paid	$1,542,771		$197,324	$74,588	$580,748	
164	Number of employees	5,649		317	119	902	

DEVELOPMENT WORK WITHOUT PRODUCTION: 1902—Continued.

Idaho.	Montana.	Nevada.	New Mexico.	North Carolina.	Oregon.	South Dakota.	Utah.	Virginia.	Washington.	Wyoming.	All other states.	
												78
				51				7				79
			4	70			1	2				80
			6	9			2	22			2	81
		1	18	8							6	82
		2	23									83
11			36		18		11		1			84
			8		19		6		3			85
6		18	53		96	2	94		32	19		86
31			6		22	1	126					87
198	5	158	90		250	70	362		59	52		88
27	7	45	2		7	1	33		12	12		89
348	315	89	8		114	270	88		212	87		90
1	19	6				1	1		13	8		91
14	45	103	2		15	18	1		44	5		92
4	1	1										93
				7					2			94
				63								95
			2	16								96
			1	4								97
			12									98
	1											99
1			12		14		2		1	3		100
2					2							101
1		5	4		21	5	18		3			102
8			1		7		11					103
7		20	1		16	13	23		9	10		104
									1			105
18	7				7	3						106
												107
			4									108
												109
												110
							3			1		111
												112
		3	1		1		2					113
									1			114
										1		115
												116
								1				117
				1								118
												119
		1										120
			1									121
		2		9								122
				5								123
				31				1				124
				9	4		4	10			2	125
2			1	1	1		2				4	126
1			4		10	1	1					127
		1	3		40		1		2	2		128
1	1	5	8		7	1	1		2	1		129
4		1			9		5		2	1		130
14	2	1	1		11	17	14	1	4	1		131
3		1					2		5			132
44	18	21	4		30	29	5		27	11		133
1					3		4			1		134
15	3	3				3	3		1	35		135
		5										136
4									1			137
1			1									138
617	347	517	304	827	620	551	833	84	460	282	6	139
626	350	475	298	341	629	543	837	87	466	243	6	140
653	316	472	299	342	691	518	850	35	449	237	6	141
692	303	504	335	343	762	485	797	38	484	249	26	142
736	428	523	322	350	842	412	883	49	491	262	26	143
856	504	542	330	327	925	458	927	54	518	320	26	144
924	506	565	413	343	952	474	918	54	547	370	26	145
1,012	538	641	391	327	902	525	967	64	542	367	27	146
1,071	613	672	460	361	908	557	963	57	528	448	27	147
1,059	638	672	401	341	856	578	1,031	55	495	394	28	148
1,085	635	658	350	338	803	548	1,118	61	516	244	6	149
943	594	635	357	364	734	615	1,108	62	444	237	6	150
		1	1	1								151
		1	1	1								152
		1	1	1								153
		1	1	1								154
		1	1	1				1				155
		1	1	1				1				156
		1	1	1				1				157
		1	1	1				1				158
		1	1	1				2				159
		1	1	1				2				160
		1	1	1				2				161
		1	1	1				2				162
$158,262	$65,797	$27,133	$58,128		$75,594		$159,059		$75,684	$69,604		163
254	810	590	1,918		187		291		198	113		164

TABLE 91.—DETAILED SUMMARY, MINES REPORTING

		United States.	Alabama.	Arizona.	California.	Colorado.	Georgia.
	Miscellaneous expenses:						
165	Total	$1,017,356	$889	$123,841	$125,755	$211,781	$485
166	Royalties and rent of mine and mining plant	$71,131		$1,400	$35,802	$19,284	$100
167	Rent of offices, taxes, insurance, interest, and other sundries	$946,225	$889	$122,441	$89,953	$192,497	$385
168	Cost of supplies and materials	$5,075,077	$1,048	$920,886	$603,492	$1,004,587	$2,287
	Power:						
169	Total horsepower	56,005	157	6,211	6,799	16,862	328
	Owned—						
	Engines—						
	Steam—						
170	Number	965	7	112	114	278	9
171	Horsepower	36,009	153	4,220	3,075	11,367	248
	Gas or gasoline—						
172	Number	219	1	95	20	86	
173	Horsepower	3,477	4	1,750	260	499	
	Water wheels—						
174	Number	193		1	96	29	2
175	Horsepower	11,524		2	2,509	2,625	80
	Other power—						
176	Number	111		9	10	61	
177	Horsepower	3,970		239	202	2,143	
	Rented—						
178	Electric, horsepower	795			597	188	
179	Other power, horsepower	230			156	40	
	Electric motors owned—						
180	Number	86		16	24	24	
181	Horsepower	2,572		177	1,153	893	

DEVELOPMENT WORK WITHOUT PRODUCTION: 1902—Continued.

Idaho.	Montana.	Nevada.	New Mexico.	North Carolina.	Oregon.	South Dakota.	Utah.	Virginia.	Washington.	Wyoming.	All other states.	
$98,217	$35,771	$70,435	$33,975	$9,647	$46,791	$45,210	$133,396	$9,702	$36,598	$34,863	.....	165
$300	$1,751	$5,638	.....	$848	$635	$250	$5,123	.....	.....	.....	.....	166
$97,917	$34,020	$64,797	$33,975	$8,799	$46,156	$44,960	$128,273	$9,702	$36,598	$34,863	.....	167
$105,058	$269,902	$454,077	$122,238	$54,332	$233,936	$166,585	$466,475	$26,305	$229,835	$110,254	$3,780	168
4,493	3,700	1,819	3,147	1,037	1,718	2,664	2,411	90	3,441	1,073	60	169
45	82	25	69	30	35	38	52	5	33	31	5	170
1,494	3,247	1,305	2,995	967	1,013	1,870	2,064	85	846	1,000	60	171
6	1	21	1	.....	11	4	14	1	7	1	.....	172
45	8	429	12	.....	97	74	232	5	59	8	.....	173
24	5	3	.....	1	15	1	2	.....	12	2	.....	174
2,779	200	40	.....	70	584	60	90	.....	2,470	15	.....	175
1	10	2	3	.....	.....	12	.....	.....	2	1	.....	176
175	250	45	140	.....	.....	660	.....	.....	66	50	.....	177
.....	.....	.....	.....	.....	.....	.....	10	.....	.....	.....	.....	178
.....	.....	.....	.....	.....	19	.....	15	.....	.....	.....	.....	179
2	2	11	.....	.....	2	.....	3	.....	2	.....	.....	180
60	76	137	.....	.....	33	.....	25	.....	18	.....	.....	181

PRECIOUS METALS RECOVERED BY CYANIDE PROCESSES

PRECIOUS METALS RECOVERED BY CYANIDE PROCESSES.

By Charles E. Munroe, Ph. D.

The returns for 1902 show that during that year there were 109 establishments, in 12 different states, using a cyanide process for the extraction of the precious metals from tailings or ores. Of these establishments, 29 cyanided the ore or tailings without other treatment; 27 crushed the ore previous to cyaniding; 5 concentrated the ore; 20 combined amalgamation for coarse gold with cyaniding for the finely divided gold; 18 combined concentration and amalgamation with cyaniding; 6 combined smelting, and in some instances amalgamation with cyaniding; and 4 combined chlorination, with and without amalgamation, with cyaniding. During the census year these establishments treated 3,089,673 tons of ore and 199,689 tons of old tailings, or 3,289,362 tons in all, and produced 776,050 fine ounces of gold, valued at $15,972,268, and 1,741,546 fine ounces of silver, valued at $871,878; the products included also 15,000 pounds of copper, valued at $1,670; 741,000 pounds of lead, valued at $12,494; and 8,726 pounds of mercury (recovered from tailings), valued at $5,620, so that the total value of all the products was $16,863,930.

The returns showed directly that of the total output of precious metals 289,305 ounces of gold, valued at $5,947,888, and 560,872 ounces of silver, valued at $287,614, were extracted from 1,156,643 tons of ore and tailings by means of some cyanide process of recovery. It is estimated that in those operations in which amalgamation, chlorination, smelting, or several of these processes were combined with a cyanide process, gold to the value of $2,000,000 and silver to the value of more than $300,000 were recovered by cyanide processes. Hence, by the use of such processes there were produced in the United States, in 1902, gold with an estimated value of about $8,000,000, and silver with an estimated value of about $600,000.

A detailed summary for cyaniding mills is presented in the report on gold and silver.

OCCURRENCE OF GOLD.

Gold, when found *in situ*, is generally in quartz veins intersecting metamorphic rocks, and to some extent in the wall rock adjoining these veins. It may occur either free or combined apparently with tellurium and perhaps selenium, and it is associated with pyrite (iron disulphide), chalcopyrite (copper-iron sulphide), galena (lead sulphide), sphalerite (zinc sulphide), mispickel (iron sulph-arsenide), and many other minerals containing sulphur, antimony, bismuth, cobalt, nickel, the platinum group of metals, etc. On exposure to the atmosphere these minerals may undergo chemical changes, whereby many of their constituents are converted into other compounds, while the metallic gold is set free. Atmospheric action also breaks the veinstone into fragments, which are ground to smaller particles by attrition. When suspended in flowing water the superior density of the gold causes the particles, together with the heavier particles of the vein matter, to settle out, through a natural concentrating action, in an obstructed portion of the stream, forming alluvial deposits or placers. Through geologic changes such alluvial deposits may again be formed into rock masses, the gold being found in conglomerate rock cemented together by finely divided material, which may be barren or may itself contain gold. When the gold occurs free in quartz or in a weathered vein, it is called a free-milling ore; when it is intimately associated with sulphurets and similar substances, it is called a refractory ore.

Free gold, as found in nature, is never pure, being alloyed to a greater or less degree with silver, copper, and other metals. It occurs in quartz in the form of strings, scales, or plates, and at times in considerable masses of aggregated crystals; the scales are often so small as to be invisible to the naked eye, so that quartz showing no "color" and no evidence of gold on panning may yet yield a considerable percentage on assay. The metal is very irregularly distributed through the quartz, being disseminated throughout its mass, and also occurring in cavities; it is in these cavities that the largest masses and most perfect crystals of gold are found. Alluvial gold occurs usually in flattened scales of different degrees of fineness, the size and shape depending partly on its original condition in place, and partly on the amount of attrition it has undergone in transport. The average fineness of the gold in a placer is determined by the assorting action of the running water that transported the materials from their point of origin; the coarser particles, requiring rapid currents to transport them, are dropped first, while the finer particles are carried long distances, sometimes scores of miles. Another agent which has borne no inconsiderable part in this transportation, delivering its burden to the streams at its base, is the glacier.

MINING AND RECOVERY OF GOLD.

Placers.—In the earlier operations in auriferous districts, the gold is obtained from the placers by the use of the pan, rocker bumper, "long tom," and sluice, and by hydraulicking. The hydraulic process was employed by the Romans, but it has probably reached its greatest development in this country, since its introduction in California in 1853. In this process, as in the workings of nature, the energy of a head of water dislodges the gold bearing detritus, and the buoying power of water at different rates of flow separates the heavier from the lighter particles. Even in ancient times, these methods were often supplemented by the use of mercury, either in the liquid state or exposed on plates, to catch and retain, by amalgamating with them, the lighter particles of gold, which would otherwise flow away with the dirt. More recently, dredging has been resorted to in order to recover the gold bearing alluvium from river beds, and even from deposits in former river beds, over which have since formed deposits of silt so deep that the water has been turned from its course.

Free milling ores.—When the placers have been exhausted, attention is given to the recovery of the gold *in situ* by vein or quartz mining. As long as the ore is free milling, the process consists in detaching it from the vein by drilling and blasting. It is then crushed by stamps, crushers, or rock breakers, and treated, like placer deposits, by sedimentation and amalgamation. The machinery and devices used for concentration, separation, and amalgamation have been very highly developed, especially during the past century. During the last half century treatment by chlorine has been resorted to for the recovery of the fine gold.

Refractory ores—old methods.—When refractory ores are reached, the methods of mining are changed. Before the introduction of the cyanide process, the gold in these ores was extracted by smelting, chlorination, or other elaborate chemical process, the degree of success depending on the richness of the ore in precious metals or in other materials that would yield a profit on the operations. Thus the precious metals associated with galena were alloyed with the lead reduced from it by smelting, and subsequently recovered by processes such as that of Parkes or Pattison; iron pyrites carrying the precious metals were roasted to convert their sulphur content into sulphuric acid, and the precious metals were then recovered from the pyrite cinder, and these methods are still employed. Copper pyrites, which usually carries gold and silver, and has long been a source from which these metals were obtained, has become a notable source of supply, since the development of Manké's method of bessemerizing copper mattes and the successful refining of this impure copper by electricity. These are a few among numerous methods proposed or used for the treatment of refractory ores. In the development of the milling processes it has become possible to assort the ore into different concentrates, each of which is treated by that process which will most effectively and economically extract the gold and other valuable substances present.

On account of the cost of transportation or treatment, however, at many mines only the most valuable of the ores could be worked profitably; moreover, after the greatest possible value had been extracted by concentration or by some other comparatively crude form of treatment, the tailings—carrying with them, in the aggregate, much gold and silver—were disposed of as inexpensively as possible. Thus, in the early days of the Comstock lode in Nevada, which has yielded gold and silver valued at more than $400,000,000,[1] the treatment of the ores was limited to mill batteries, amalgamating pans, and settlers, the tailings—still containing notable quantities of the precious metals—being deposited in the canyons leading to the Carson river. Later, blanket sluices, riffles, and other devices were employed to catch the rich sulphurets that had escaped previous treatment, as well as quicksilver and amalgam from the plates; in addition, restraining dams and reservoirs were constructed at favorable points in the two canyons, and along the edges of the river, to catch the tailings and the rich chloride slums or settlings, but both the dams and their accumulations were sometimes swept away by winter floods. Since the erection, in recent years, of several cyanide plants at Silver City and Six Mile Canyon to work these tailings, it has been estimated, on the basis of the values recovered from the tonnage work, that the value of the precious metals swept into the river and spread over its erratic bed and sandy flats aggregated $60,000,000. This estimate is supported by the results obtained in attempting to recover some of these values from the river bed by dredging and other means.

[1] Report of the Director of the Mint upon the Production of the Precious Metals during 1902, page 158.

All of the long-used methods have been open to criticism with regard to efficiency or economy. Thus, in the working of placers or free milling ores, sometimes the finest particles of gold were not precipitated by the riffle bars or caught on the blankets, but floated away with the slimes; again, the grains of gold were often "rusty," or so coated as to refuse to amalgamate when brought in contact with the mercury, and hence, in spite of the use of metallic sodium, or of potassium cyanide and other chemicals, much gold escaped; or the presence of lead, copper, arsenic, antimony, or other substances in the ore caused the mercury to become "foul," and therefore unable to take up gold. These, combined with other causes of loss, have led to the estimate that although gold to a value of over $1,000,000,000 has been produced in California since 1848, "yet more has been wasted in milling and hydraulic mining by being washed down the rivers and even to the ocean."

Such were the conditions that existed in 1888, when, by tests made on a large scale, it was demonstrated that the cyanide process for the recovery of gold and silver from low-grade ores was of practical value and low cost, making it possible to work profitably the large bodies of low-grade ore scattered over the earth, and the enormous piles of tailings accumulated around both abandoned and active mines and mills and being continually added to as mining and milling proceeded.

THE CYANIDE PROCESS.

History.—According to Hoefer,[1] prussic acid appears to have been known to the Egyptian priests, who used it for poisoning initiates guilty of divulging the sacred mysteries. According to Eissler,[2] the fact that gold when in a fine state of division was soluble in cyanide of potassium was already known in the Middle Ages, when the gilding of metals was carried out by jewelers and alchemists by the use of gold in cyanide solutions. Unless potassium cyanide was at that time made from prussic acid obtained from vegetable sources, it is difficult to reconcile this with the statements made by Watts, by Roscoe and Schorlemmer, and other authorities, that potassium ferrocyanide was discovered by Macquer in 1752 and hydrogen cyanide by Scheele in 1782; for these, particularly the former, are the present sources of potassium cyanide. It has long been known, however, that in the kernels of the bitter almond, peach, apricot, plum, cherry, and quince, in the blossoms of the peach, sloe, and mountain ash, in the leaves of the peach, cherry laurel, and Portugal laurel, in the young branches of the peach, in the stem bark of the Portugal laurel and mountain ash, and in the roots of the mountain ash, there occur certain glucosides which, through the action of an enzyme in the presence of water, become hydrolyzed, yielding hydrogen cyanide, or prussic acid, as one of the products.

[1] Histoire de Chemie, Vol. I, page 226.
[2] The Metallurgy of Gold, 1896, page 378.

The solubility of gold and silver compounds in cyanide solutions was demonstrated by Scheele on pages 405 and 406 of his chemical essays. According to Gore,[3] it was the reading of this passage in Scheele's work which in 1840 suggested to John Wright, of Birmingham, England, the suitability of cyanides of gold and silver, dissolved in solutions of alkaline cyanides, for use in electroplating. This plan was immediately tested with solutions of silver, first in potassium ferrocyanide and later in potassium cyanide, and the results were so successful that this method of electroplating was embodied in a British patent issued to G. R. and H. Elkington, March 25, 1840. This patent became the basis of the arts of electro-silvering and electro-gilding which have been so extensively practiced ever since. It was in 1840, also, that the solubility of the metals themselves was taken advantage of, for in Mason's "separate battery," devised in that year, the necessity of supplying additional metallic salt to the bath as the deposition went on was obviated by the use of an anode composed of the metal to be deposited on the object suspended at the cathode.

In "The Cyanide Process, its Practical Application and Economical Results,"[4] Scheidel says:

> The first record, in scientific literature, of experiments in which metallic gold was dissolved in a cyanide of potassium solution consists in Prince Pierre Bagration's paper in the Bulletin de l'Academie Imperiale des Sciences de St. Petersbourg, 1843, tome 11, page 136. Bagration, who alludes to Elkington's process, preserved cyanide of potassium solution in a dish gilded on the inside. He noticed that after eight days the whole gold surface had been attacked. He experimented then with finely divided gold under the influence of the galvanic current. The latter he soon recognized as not of any benefit in the dissolving process. He precipitated the gold out of the cyanide solution by means of the electric current on a cathode of copper. Continued experiments proved the advantage of higher temperature during the dissolving process, and taught the precipitation of gold from its still warm solution by means of silver or copper plates, without the electric current. The higher temperature had, however, the disadvantage of the silver and copper being strongly attacked by the cyanide solution during the precipitation process. Bagration extended his experiments to solutions of ferrocyanide, which he found to act like cyanide, but in a much less degree. He further studied the solubility of gold in the form of plates in cyanide and found it to be dissolved in such form at a considerable rate at a temperature of 30° to 40° C. He noticed the influence of the air on the reaction. Bagration believes that hydrocyanic acid in a state of generation is a gold solvent, and he concludes his paper with the remark that in the future cyanide of potassium must be enumerated among the solvents of gold. L. Elsner published in J. fr. Chem., 1844, page 441, his observations on the reactions of "reguline metals" in an aqueous solution of cyanide. He found that gold and silver were dissolved in potassium cyanide without decomposition of water. "The dissolution of the metals is, however, the consequence of the action of oxygen which, absorbed from the air, decomposes part of the cyanide." His reaction has been expressed by others in the following equation:

$$\underset{\text{(Gold.)}}{2\,Au} + \underset{\text{(Cyanide of potassium.)}}{4\,KCy} + \underset{\text{(Oxygen.)}}{O} + \underset{\text{(Water.)}}{H_2O} = \underset{\text{(Auro-potassic cyanide.)}}{2\,AuKCy_2} + \underset{\text{(Potassic hydrate.)}}{2\,KOH}$$

[3] The Art of Electro-metallurgy, 1877, pages 19 and 20.
[4] California State Mining Bureau, Bulletin No. 5, 1894, page 9.

It is generally called Elsner's equation. Some years after, Faraday made use of the solubility of gold in cyanide solution for reducing the thickness of gold films. (Experiments on the relations of gold and other metals to light, Transactions of the Philosophical Society, 1857, page 147.) The basis of the most modern process for the extraction of gold was thus provided.

In confirmation of Elsner's theory as to the action of oxygen, which has been disputed, it may be noted that V. Lehner has recently shown [1] that gold will dissolve in common acids, like sulphuric and phosphoric, if oxygen be present in the solution, and that the solubility of gold in selenic and telluric acids is due to the fact that at the temperature which obtains in the reaction these acids are themselves broken up into dioxides and oxygen.

The first instance of an attempt to apply this solvent action of the cyanides to the extraction of precious metals from their ores or other bodies containing them appears in United States Patents 61866 and 62776, issued to Dr. Julio H. Rae, of Syracuse, N. Y., on February 5 and March 12, 1867. Dr. Rae claimed the use not only of potassium cyanide as a solvent for the precious metals in the ore, but also of an electric current in precipitating them from the solution, and of rotatory or movable electrodes. This was followed by United States Patent 229586, of July 6, 1880, to Thomas C. Clark, of Oakland, Cal., who roasted his ore to a red heat, and placed it, in this condition, in a cold bath containing salt, prussiate of potash, and caustic soda; United States Patent 236424, of January 11, 1881, to H. W. Faucett, of St. Louis, Mo., who subjected hot crushed ores, under pressure, to the action of sodium cyanide in solution; and United States Patent 244080, of July 12, 1881, to John F. Sanders, of Ogden, Utah, who treated his ore with potassium cyanide and glacial phosphoric acid. But in each of these last three patents the object was to cleanse the gold previous to amalgamation, potassium cyanide having been used for a considerable time, in California and Australia, for removing the coatings from rusty gold in the pan amalgamation process.

In 1884 Astley P. Price applied for British Patent 5125, for the use of zinc in a state of fine division in precipitating gold or silver from solutions containing them. On July 28, 1885, United States Patent 323222 was issued to Jerome W. Simpson, of Newark, N. J., covering the extraction of gold, silver, and copper from their ores by means of solutions containing potassium cyanide, ammonium carbonate, and sodium chloride, and the subsequent precipitation of the dissolved metals by means of pieces or plates of zinc suspended in the solution. A caveat for the use of cyanide was filed in the United States Patent Office by F. M. Endlich and N. W. Mühlenberger, during the same year, but was subsequently abandoned. At Park City, Utah, about the same time, Louis Janin, jr., made experiments with cyanide in extracting silver and gold from ores, which led to his filing a caveat on May 1, 1886. He did not press this to an issue, but he published his results in the Engineering and Mining Journal, 1888.[2] W. A. Dixon also made experiments with cyanide on Australian ores, and recorded his results in a paper read before the Royal Society of New South Wales.

The cyanide process acquired commercial value in 1887, when John S. MacArthur and W. Forrest, of Glasgow, Scotland, applied, on October 19, for their English patent covering the use of dilute solutions of cyanides in the extraction of the precious metals. Later they obtained a patent for the use of zinc as a precipitant in a particular state of subdivision.

The commercial value of the cyanide process was demonstrated by tests made on a large scale, with ore from the New Zealand Crown mine, in June and July, 1888. Commercial success dates from the introduction of the MacArthur-Forrest process, in 1890, in the Witwatersrand gold fields in South Africa, the first cyanide plant in the world for treating tailings having been erected at Johannesburg in April, 1890.[3] In the Witwatersrand alone, at the end of 1891, there were 6 companies treating tailings by the cyanide process; at the end of 1892 there were 22; and at the end of 1893 there were 32, with a record of 143,500 tons per month treated. By the use of this process there were recovered in the Rand 286 ounces of gold in 1890, 34,862 ounces in 1891, 178,688 ounces in 1892, 330,510 ounces in 1893, 714,122 ounces in 1894, 753,490 ounces in 1895, and 703,704 ounces in 1896; the output then increased up to September, 1898, when the commencement of active hostilities in the Boer War interfered with the active working of the mines.

Methods.—The cyanide process consists in lixiviating the finely powdered ore with a dilute solution of an alkali cyanide, drawing off this solution when charged with the precious metals, and precipitating these metals from the solution. In the patents of MacArthur and Forrest the claims were made for the use of dilute solutions of cyanide (not more than 8 parts of cyanogen to 1,000 parts of water); the employment of caustic alkalies for neutralizing acid ores, prior to their digestion in the cyanide solution; and the use of zinc, preferably in a filiform condition, as a precipitant. The cyanide first used was potassium cyanide, but cyan-salt, which is a mixture of sodium and potassium cyanides, has come into extended use. The tailings, or a charge of ore crushed to the desired fineness, are placed in the leaching vats or tanks and, if acid, given a preliminary treatment with lime or sodium hydroxide, which is generally washed out before further treatment. The ore is then subjected to the action of the cyanide solution, which is usually admitted at the bottom of the leaching vat; after digesting for a length of time, depending on the

[1] Journal of the American Chemical Society, 1904, Vol. 26, pages 550 to 555.

[2] Page 548.

[3] Alfred James, Cyanide Practice, frontispiece, 1902.

character of the charge, its fineness, its freedom from slimes, and the strength of the cyanide solution, the solution containing the precious metals is drawn off and the operation repeated. According to Elsner's equation and the elaborate investigations of MacLaurin and Christy, the presence of oxygen in the solution is essential, hence many operators use sodium peroxide or other oxidizing agents with their cyanide solutions.

The leaching or percolation vats vary much in form, dimensions, and construction. Thus they may be of wood, barrel-shaped, 22.5 feet in diameter and 4 feet deep, and holding a charge of 30 tons; or of concrete, rectangular, 50 by 40 feet in area and 4 feet deep, and holding 150 tons.

The following facts from Packard's paper on "The Cyanide Process in the United States"[1] indicates the wide ranges of variation in methods:

In the Mercur district the ore is covered with solution, which is allowed to stand from thirty minutes to six hours and then drawn off. This operation is repeated from eight to thirty-five times. Here the material leached is so coarse that there is no danger of "packing." Each operation of covering takes from two to six hours. A few mills cover the pulp with solution, allow it to stand forty-eight to ninety-six hours, draw it off, and wash. Many of the mills follow the strong solution with a wash of weak solution (one-tenth per cent or less). This is in turn followed by a water wash, which flows through the zinc boxes into the weak solution tank and becomes the first wash for the next charge.

In the extraction processes referred to above the treatment with cyanide solutions is accomplished by percolation. This method is widely and successfully used, but it has its disadvantages. If the material treated is a clean sand, the solution penetrates throughout the mass, exerting its full solvent effect, and the subsequent draining and washing are easily accomplished. But if the ore contains some kind of rock which is converted by the crushing into a powder that when moistened produces slimes—a formation which is most marked when the rock is of a clayey nature—the presence of these ore slimes in the leaching vats may retard or even prevent percolation, according to their amount and character. In working ores of this kind, the difficulty has been obviated by coarse crushing, but in that case gold is lost, because the solvent can not penetrate through the coarser granules of ore to the inclosed grains of metal. To overcome these defects in the process, resort is had—as in the Pelatan-Clerici process, or in the use of the Aurex sluice—to agitation during exposure to the cyanide solution. Furthermore, since in these processes amalgamation and precipitation are carried on nearly simultaneously with solution, not only is the coarse gold quickly removed, but the rusty gold is made capable of amalgamation through being cleansed by the action of the cyanide and the electric current, which are employed simultaneously, while the float gold is either amalgamated directly or dissolved and then precipitated. In these processes the precious metals are recovered as amalgams, which need only retorting and melting to be ready for the mint.

A novel method of overcoming the impermeability of slimes is found in the suggestion of Count von Schwerin,[2] who proposes to remove water from wet clay and similar amorphous fine slimes by passing through the mass an electric current, whereby the water is driven to the cathode and the solid particles to the anode by "electric endosmosis." The apparatus consists of a wooden vat having for a bottom a brass netting, which forms the cathode; the water being drawn to the netting quickly runs off.

In the MacArthur-Forrest process, the cyanide solution containing the gold and silver is next run into zinc boxes for the precipitation of the precious metals. The zinc boxes, like the leaching vats, vary in character at the different works. A form in common use in the United States is made of 2-inch dressed plank, bolted together and painted with paraffin paint; it is divided into six compartments, 13 by 20 inches in cross section and 20 inches deep, and is provided with a screen about 4 inches above the bottom, on which to place the zinc shavings. About sixty pounds of shavings are required to fill the box. It is provided with an inlet and an outlet pipe, and in the bottom of each compartment is placed a 1-inch pipe closed with a stopcock, through which the slimes are drawn off in cleaning up. The circulation in the zinc box is secured by having the first partition of a compartment extend from the top of the box to within 3 inches of the bottom, while the second partition extends from the bottom of the box to within 2 inches of the top. The screen for the zinc shavings is stretched between. The solution from the entrance pipe falls to the bottom of the box, passes under the first partition, rises up through the zinc shavings, flows over the second partition, and thus proceeds up and down from compartment to compartment until it reaches the exit pipe of the box. The Mercur mill is equipped with long sheet-iron boxes having wooden partitions wedged into place; these can easily be removed for cleaning up, the slimes being all brushed together. At the Cripple Creek mill, the slime discharge pipes of the zinc boxes lead from the side of each compartment and discharge the slime into a trough leading to a tank.

When the potassium cyanide solution comes into contact with the gold in the leaching vat, the gold is dissolved, forming potassium aurocyanide, according to the following equation:

$$4\ KCy + 2\ Au + O + H_2O = 2\ KAuCy_2 + 2\ KHO.$$

[1] Transactions of the American Institute of Mining Engineers, Vol. XXVI, pages 709 to 721.

[2] Zeitschrift der Elektrochemie, 1903, page 739.

According to Christy,[1] when the solution of potassium aurocyanide, containing, as it usually does, an excess of potassium cyanide, is brought into contact with the zinc, the reaction may be represented by

$$2\ KAuCy_2 + 3\ Zn + 4\ KCy + 2\ H_2O = 2\ (ZnCy_2\ .\ 2\ KCy) + K_2O_2Zn + 2\ H_2 + 2\ Au;$$

but in the absence of free potassium cyanide the successive reactions taking place may be summed up in the following equation:

$$4\ KAuCy_2 + 4\ Zn + 2\ H_2O = 2\ ZnCy_2 + ZnCy_2\ .\ 2\ KCy + K_2O_2Zn + 2\ H_2 + 4\ Au.$$

Christy also says:

According to the substitution reaction, one atom of zinc replaces two atoms of gold, or 1 ounce of zinc should precipitate 6.2 ounces of gold; whereas, as everyone knows, in practice 1 ounce of zinc will precipitate only one-fifth to one-fifteenth of an ounce of gold, or thirty to ninety times less than the amount called for by the reaction by substitution. According to the reactions I have suggested, in the absence of free cyanide of potassium and caustic potash 1 ounce of zinc should precipitate 3.1 ounces of gold; in the presence of a moderate excess of cyanide of potassium it should precipitate 2.06 ounces. The apparent discrepancy that seems still to remain between theory and practice is in reality due to the facts, first, that the free alkali (potash in particular) formed in the solution of the gold, or added to neutralize the free acid in the ore, also dissolves the zinc as potassium zincate; second, that an excess of potassium cyanide dissolves the zinc on its own account, both as the double cyanide and as the zincate of potassium; third, it should also be remembered that water containing dissolved oxygen attacks metallic zinc quite vigorously, forming hydrate of zinc.

According to Packard, the 60 pounds of zinc shavings required to fill the zinc boxes described above will precipitate the gold from about 1,500 pounds of 0.2 per cent solution per hour, the solution carrying from 0.1 to 0.8 ounce of gold per ton on entering the zinc box, and from 0.01 to 0.05 ounce on leaving it. The gold in wash waters and weaker solutions is less easily precipitated, a much longer contact with the zinc being required.

On cleaning up, the zinc shavings are washed and the finely powdered portions, called zinc-gold slimes, are screened through sieves varying in mesh, at the different mills, from one-fourth-inch mesh to 60-mesh, the coarse stuff being returned to the zinc box. In this country, where the zinc-gold slimes are treated at the mills, they are subjected to the action of an acid, such as sulphuric, which removes much of the zinc and other soluble bodies, and the residues are then washed, dried, fluxed, and melted. A few mills ship these slimes to smelters and refiners, but the difficulty of obtaining a satisfactory sample, and the almost constant wide disagreement between buyer and seller have led many smelters to refuse to handle them.

In discussing Professor Christy's paper Mr. Francis L. Bosqui stated[2] that at Bodie, Cal., after many discouraging failures, the following method of operating in treating the zinc-gold slimes was adopted, and has been followed with entire success:

The slimes and fine zinc are discharged directly from the zinc boxes into a redwood vat 6 feet in diameter and 2 feet deep. This vat is protected on the inside by several coats of paraffin paint, has a slight bottom incline for drainage, and is provided with a 2-inch discharge valve. Here the slimes are treated with sulphuric acid. After the destruction of the zinc, the zinc sulphate and the slight excess of acid present are diluted by filling the vat with warm water. Within an hour the bulk of the precipitate will have settled to the bottom. The supernatant liquor, to the amount of about 400 gallons, which still contains a small amount of gold slimes in suspension, is then siphoned off into a 10-ton settling vat.

The gold slimes are treated with a succession of these washes, the supernatant liquor being each time drawn off into the settling vat, until the amount of zinc sulphate remaining in the slimes is insignificant. The liquor siphoned off into the settling vat, which contains only a very small quantity of slimes in proportion to the total quantity obtained, is left to settle between clean-ups. The clear liquor is drawn off just before a succeeding clean-up, and at long intervals the precipitate is gathered from the bottom and melted.

The bulk of the slimes is finally discharged from the acid vat into a filter box. This box is provided, about a foot from the top, with a perforated partition which is closely covered with two thicknesses of ordinary mill blanketing. From the compartment beneath this filter the air is withdrawn by means of a steam ejector, and the water is thus removed from the slimes by suction. At the bottom of the box is a 1-inch discharge valve for drawing off the accumulated clear liquid. By occasionally scraping the filter blankets the passage of water through them is greatly facilitated. These blankets are removed and washed after each clean-up, and clean ones are substituted. The partially dried slimes from the blankets are then completely dried over a furnace and melted in crucibles. The zinc residues being thus pretty thoroughly removed from the slimes, the difficulties in melting are reduced to a minimum. * * *

For some time a considerable value went into the slag, which had to be shipped to the smelting works. But after a good deal of experimentation a very suitable flux has been found, which reduces the slag value to almost nothing. A dust chamber has been constructed in connection with the melting furnace, and an effective damper introduced in the course of the flue. The latter is closed at each charging of the crucible, and "dusting" is thus almost entirely avoided.

Our loss in melting has never been more than barely appreciable, and now, since the introduction of a dust chamber and damper, is wholly insignificant. The wonderfully close correspondence between our actual bullion yield and the extraction indicated by careful assays of charged and discharged tailings would in itself weaken the supposition of any considerable loss in melting. To be sure, our bullion is low grade, but we suffer no inconvenience from this except the small increase in cost of transportation and refining in proportion to the value of the bars.

[1] Transactions of the American Institute of Mining Engineers, Vol. XXVI, pages 735 to 772.

[2] Transactions of the American Institute of Mining Engineers, Vol. XXVII, pages 837 to 846.

Precipitants other than filiform zinc are sometimes employed to throw down the gold. Thus, at the Delamar mine, Nevada, the precipitation is by zinc dust,[1] with agitation: Molloy precipitates with sodium or potassium amalgam, Moldenhauer with aluminum, Johnston with pulverized carbon, Christy with cuprous chloride, and De Wilde with cupric sulphate. Precipitation is effected also by electricity, amalgamated copper plates being used in the Pelatan-Clerici process, and thin lead plates as cathodes, with iron anodes, in the Siemens-Halske process.

Electro-deposition processes seem to possess an advantage over zinc precipitation processes in that the presence of caustic soda makes no difference in the result, and that they are as effective with a weak as with a strong solution. Very weak cyanide solutions may therefore be used in the leaching vats. Charles Butters, who has been closely identified with the development of the cyanide process from its introduction into this country in practical form, and has had extensive professional experience in South Africa, says[2] that in our more modern plants the electrolytic and zinc processes are now used in combination for the recovery of the metal from cyanide solutions. The solution is first cleaned by the electrolytic process. It extracts from 90 to 94 per cent of all the products, including practically all of the copper. About 8 to 9 per cent of the electric box capacity is then filled with zinc, which, aided by the electric current, removes the small quantities of gold and silver remaining. By this combination the zinc is constantly at its best, as everything that would injure the surface of the zinc as a precipitating surface has been eliminated by the previous electrolytic treatment. At Butters' mines, in Salvador, an extraction of about 99 per cent of the values in solution is made on regular monthly runs. This process is used also at Virginia City, Nev., and at Minas Prietas, Mexico.

The following tables from Packard's paper clearly set forth some of the variations which obtain in the use of the cyanide process with precipitation by zinc in practice, with the results:

[1] S. F. Emmons, Transactions of the American Institute of Mining Engineers, Vol. XXXI, pages 658 to 683.

[2] Electro-chemical Industry, Vol. II, page 207.

Description of ores used in cyaniding, with precipitation by zinc.

MILL AT—	CHARACTER.	COMPOSITION.					
		SiO_2.	Fe.	Al_2O_3.	$CaCO_3$.	S.	Other elements.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Mercur, Utah	Porphyry and limestone	70 to 80	...	5 to 10	...	...	As, Hg.
Sunshine, Utah	Decomposed porphyry and quartz	70 to 80	...	5 to 10	12 to 15	Little.	As, Sb, Te.
Bingham, Utah	Sandy quartz, with iron oxidized from sulphides and bunches of lead carbonate.	...	...	...	Little.	...	As, 0.2 per cent; Cu; much free acid.
Gilt Edge, Mont	Porphyry and limestone	...	...	...	...	...	
Cooke, Mont	Decomposed porphyry	84	3.6	2.6	[1]0.6	0.3	
Black Hills, S. Dak	Silica, with iron in varying conditions	80 to 95	Varies.	...	...	Varies.	Traces of Cu, Mn, As, Sb, Te.
Cripple Creek, Colo	Porphyry	...	...	...	[2]1 to 3	Small.	

[1] Calcium. [2] Calcium oxide.

Methods of treatment and results in cyaniding, with precipitation by zinc.

MILL AT—	Capacity, tons per day.	Size of ore leached mesh.	Preliminary treatment.	Strength of cyanide solutions.	Number of hours leached.	Cyanide consumed per ton of ore treated.	Zinc consumed per ton of ore treated.	ASSAY OF ORE.		Extraction of gold.	Cost per ton.
								Gold.	Silver.		
		Inches.		*Per cent.*		*Pounds.*	*Pounds.*	*Ounces per ton.*	*Ounces per ton.*	*Per cent.*	
Mercur, Utah	200	3/4	None	0.20 to 0.25	48	0.60	...	0.5 to 6.0	...	80 to 87	$0.85
Sunshine, Utah	60	1/4	Lime	0.06 to 0.20	48	0.75	0.30	...	...	...	...
Bingham, Utah	40	1/4	Sodium dioxide	0.025 to 0.125	120	1.0	0.30	0.25	2.0	80	1.85
Gilt Edge, Mont	50	20	None	0.15	72	0.2	0.25	0.45	...	75	1.25
Cooke, Mont	25	16-20	Lime	0.25	48	1.5 to 2.0	0.25	Variable.	...	...	...
Black Hills, S. Dak	40	30	Lime	0.50 to 0.75	96	1.25	...	0.3 to 0.9	...	85	2.50
Cripple Creek, Colo	75	40	Various, lime	0.05 to 0.75	100	1.0 to 2.0	0.25 to 0.50	1.0	0.2	90	...

Mr. W. H. Davis has discovered that by subjecting foul cyanide solutions to the action of alternating electric currents the solutions are not only regenerated, owing to the precipitation of the foul matter present, but the resultant solution is more active and has a higher solvent power than a normal cyanide solution. He attributes this increased efficiency to cyanogen which has been set free in the electrolysis, being held dissolved in the solution. This process of treatment was introduced on a working scale at the Smuggler-Union mines, Colorado, in May, 1902, and it is claimed that by its use tailings carrying as low a value as $1.80 per ton have been treated at a profit, the average cost of treatment being 50 cents per ton. The published statement[1] of the manager of these mines, comparing the results of the operations for the four months preceding with those for the four months succeeding the introduction of this process for regenerating the foul solutions, states that the application of the process resulted in a reduction of 29.73 per cent in the quantity of potassium cyanide consumed and an increase of 17.09 per cent in the quantity of gold and of 4.81 per cent in the quantity of silver extracted.

The results of simultaneous cyaniding, agitation, amalgamation, and electro-deposition are set forth in the following table, given by T. M. Chatard and Cabell Whitehead:[2]

[1] Report of the Director of the Mint upon the Production of the Precious Metals during 1902, pages 99 to 101: 1903.

[2] Engineering and Mining Journal, Vol. LXIX, page 139.

Results of simultaneous cyaniding, agitation, amalgamation, and electro-deposition.

ORE USED.	Screen mesh.	Length of run.	ORE ASSAY.		TAILINGS ASSAY.		EXTRACTION.		STRENGTH OF CYANIDE SOLUTION.			ELECTRIC CURRENT.	
			Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Start.	End.	Loss.	Volts.	Amperes per square foot.
		Min.	*Ounces.*	*Ounces.*	*Ounces.*	*Ounces.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		
Heavy (60 per cent) sulphuret ore, North Carolina	60	75	1.075	1.23	0.20	0.60	81.41	51.00	0.181	0.064	0.067	1.85	0.20
Telluride ore, oxidized, very slimy, Cripple Creek, Colo	60	60	0.90	0.60	0.10	0.35	88.90	42.00	0.190	0.155	0.035	2.10	0.17
	60	45	0.90	0.60	0.10	0.45	88.90	33.00	0.184	0.152	0.032	2.01	0.23
Telluride, like No. 2, Cripple Creek, Colo	60	60	0.95	0.65	0.12	0.38	87.47	41.51	0.185	0.134	0.051	2.20	0.26
	60	60	0.95	0.65	0.07	0.28	92.63	56.92	0.250	0.164	0.086	2.30	0.23
Telluride oxidized, dark red, very slimy, Cripple Creek, Colo	60	60	4.55	1.45	0.12	0.38	97.38	73.80	0.163	0.081	0.082	1.01	0.18
	60	75	4.55	1.45	0.10	0.25	97.81	82.76	0.164	0.129	0.035	1.80	0.19
Heavy sulphuret, Boulder county, Colo	60	60	0.40	1.30	0.12	0.60	70.00	54.60	0.150	0.059	0.091	2.02	0.22
Heavy sulphuret, South America[1]	60	60	1.05	4.35	0.60	2.55	42.85	41.38	0.180	0.078	0.102	2.02	0.23
Republic Mine, Washington	60	60	6.30	6.15	2.10	2.80	66.66	54.49	0.287	0.201	0.086	2.10	0.26
Republic Mine, finer ground	80	75	6.30	6.15	1.45	1.90	77.00	60.18	0.289	0.209	0.080	2.30	0.21
Republic Mine, still finer	100	75	6.30	6.15	0.48	1.02	92.38	83.41	0.231	0.164	0.067	2.63	0.14
Rich ore, Virginia, contains galena, etc	100	90	33.98	....	1.66	....	95.05	....	0.292	0.185	0.107	2.78	0.73
Republic Mine, Washington, mill pulp	100	90	2.50	3.75	0.40	1.55	84.60	60.00	0.170	0.105	0.065	3.27	0.67
Republic Mine, Washington, mill pulp	100	60	2.50	3.75	0.25	0.75	90.00	79.20	0.245	0.190	0.055	3.03	0.67
Republic Mine, Washington, mill pulp	100	60	2.50	3.75	0.20	2.25	92.00	40.00	0.320	0.225	0.095	3.10	0.50
Republic Mine, Washington, mill pulp	100	60	2.50	3.75	0.135	1.36	94.60	63.60	0.277	0.202	0.075	3.00	0.50
Republic Mine, Washington, coarse ore	60	60	2.30	2.50	0.375	1.025	88.70	58.80	0.198	0.099	0.099	No meter.	0.45
Republic Mine, Washington, coarse tailings	100	60	0.45	1.30	0.25	1.125	44.44	13.46	0.117	0.080	0.037	3.00	0.33
Republic Mine, Washington, coarse tailings	100	90	0.45	1.30	0.25	1.10	44.44	15.37	0.155	0.095	0.056	No meter.	0.48
Rough mill concentrates, Georgia	40	90	0.80	0.50	0.125	0.37	84.37	26.00	0.149	0.093	0.056	No meter.	0.48
Sulphuret ore, Georgia	40	90	2.68	1.00	0.27	0.50	89.92	50.00	0.276	0.214	0.062	2.8	0.57
Silver ore, Honduras[2]	100	90	0.71	72.86	0.10	6.00	85.91	91.76	0.263	0.175	0.088	4.0	0.83
Free quartz, California	100	90	0.475	0.92	0.05	0.525	89.49	44.02	0.235	0.140	0.095	2.6	0.94

[1] Contained arsenic and antimony.

[2] Contained silver chloride.

In this connection it may be noted that in Wagner's Chemical Technology[3] there is described a method of treating refractory ores, invented by W. Crookes, which consists in subjecting the powdered ore to the action of an alternating current in the presence of a solution of mercuric cyanide or of some other soluble salt of mercury.

The methods used in the Witwatersrand have been described recently by John Hays Hammond,[4] as follows:

The following description applies to the treatment of ores in the pyritic zones. Ores from the upper (oxidized) horizons of the reefs, which constitute but a small percentage of the ores treated, require a slight modification of the process.

The ground near the mines is level, and does not permit transportation by gravity; consequently the ore must be first elevated into the ore bins at the mill, and the tailings leaving the mill must be elevated for treatment by the cyanide process. This is done either by tailing pumps or, preferably, by tailing wheels. These are from 40 to 50 feet in diameter, and discharge the tailings into a launder, which, with a grade of about 3.5 per cent, carries them to the cyanide works. The auriferous pyrites are, to a large extent, taken out as concentrates by means of Spitzlutten (hydraulic classifier). About 10 per cent of the mill pulp recovered in this way consists of pyrites with coarse sand, a concentration of 10 to 1 being obtained. These concentrates are taken to tanks for separate treatment. From two to three weeks of treatment is required in order to obtain from this material a recovery of from 90 to 95 per cent of the gold it contains. A solution of about 0.25 to 0.3 per cent of cyanide of potassium is used. After passing over the Spitzlutten the tailings are run to Spitzkasten (pointed boxes), where the heavier sands are allowed to settle, while the lighter material (slimes) overflows, and is carried to the slime works for special treatment. The sands which settle in the Spitzkasten, representing about 70 per cent of the battery pulp, are continuously discharged by pipes leading from the bottom of the box, and are delivered by a hose or by an automatic revolving distributor to settling tanks, into which they are so fed as to be as thoroughly mixed as possible. This separation of the sands from the slimes has to be carefully made, so as to remove all clayey substances, the presence of which would otherwise prevent rapid percolation of the solution and the free access of atmospheric oxygen, which is essential to the solution of gold by cyanide.

Most of the modern plants have a system of double treatment, the tailings being settled in the settling tanks, when they are treated, after being allowed to drain, with a weak solution of cyanide of potassium. This addition of the cyanide of potassium is made rather for the purpose of saturating the sands with the solution than for thorough leaching, which would be difficult on account of the packing of the sands as they are settled, rendering percolation difficult. After the solution has been drained off, the sands from the settling tanks are discharged into the leaching

[3] Manual of Chemical Technology, R. von Wagner, translated by W. Crookes, 1892, page 191.

[4] Transactions of the American Institute of Mining Engineers, Vol. XXXI, pages 817 to 854: 1902.

tanks, placed immediately below the settling tanks, from which they are filled from discharge doors on the bottom of the latter. For a 200-stamp plant 16 steel settling and 16 steel leaching tanks are usually employed. From 3 to 4 settling and leaching tanks are used for the treatment of the Spitzlutten concentrates above described. The settling tanks are usually 40 feet in diameter and 9 feet high. The leaching tanks have the same diameter, but usually a foot less height. The capacity of these tanks is about 400 tons of pulp each.

In the leaching tanks the pulp is subjected to three treatments with cyanide of potassium. Where the MacArthur-Forrest process is used, the strong solution contains 0.25 per cent, the medium solution 0.2 per cent, and the weak solution 0.10 per cent of KCy. In the Siemens-Halske process the solutions are weaker, namely, the strong solution, 0.10; medium, 0.02; and weak, 0.01 per cent of KCy.

The treatment requires from four to seven days. From 130 to 150 tons of solution are usually employed for 100 tons of sand. After being allowed to drain, the sands are discharged through bottom discharge doors into trucks, in which they are removed to residues or tailings heaps. Here, again, elevation is necessary, on account of the flatness of the country, and is usually effected by the endless rope system. These tailings heaps are conspicuous throughout the mining district. By reason of the heavy winds prevailing at certain seasons of the year, they are becoming a great nuisance, and the question of their future disposition is one of the problems for the mining engineer.

The cyanide solution, after being drawn off from the leaching tanks, is taken to the precipitation boxes. The gold from the strong solution is precipitated in one set and that from the weak solution in another set of boxes. Precipitation is effected by either the MacArthur-Forrest or the Siemens-Halske process.

The MacArthur-Forrest process.—In this process the gold is precipitated by zinc, the solution passing upward through a succession of compartments, in which are placed zinc shavings or filings, resting on a movable tray of coarse screening. About twenty precipitation boxes, 20 feet by 3 feet by 3 feet 9 inches in size, are used. The gold bearing solution is brought into close contact with the zinc, causing the deposition of the gold, partly as a metallic coating on the zinc and partly as gold slimes, which sink to the bottom of the box. As the zinc is gradually dissolved by cyanide more is added.

Once or twice a month the boxes are emptied, and the gold slimes are treated with dilute sulphuric acid, then dried and melted in crucibles. The dried slimes contain about 15 to 20 per cent of gold, and after fluxing with borax and soda an ingot of 0.750 to 0.800 fineness in gold and 0.100 in silver is obtained. The slag, carrying from 5 to 50 ounces of gold per ton, is usually sold to smelters.

This precipitation process yields satisfactory results only with solutions containing more than 0.1 per cent of cyanide, the weaker solutions not being acted upon by zinc. An improvement of the method is the addition of lead to the zinc, whereby the combination of the two metals forms a galvanic couple, which also reacts with weaker solutions, such as are employed, for example, in the treatment of slimes.

The Siemens-Halske process.—In this process the solution flows through compartments very similar to the zinc boxes above described, but the zinc shavings are here replaced with lead strips (0.1 pound per square foot) or shavings hung between iron plates placed vertically and longitudinally in the box, about 4 inches apart. The lead strips are connected with the negative, and the iron plates with the positive, pole of a dynamo, and the solution is thus electrolytically decomposed, the gold being plated on the lead cathode. The iron plates are wrapped in canvas to prevent short circuiting. The current employed is from 2 to 3 volts, giving a current density of about 0.06 amperes per square foot of cathode. Once a month the lead sheets are removed and replaced, and the gold coated lead is melted and cupelled, yielding a bullion of 0.880 fine in gold and 0.100 in silver. The litharge is sold to smelters. The solutions passing through the treatment boxes are collected in tanks, and are made up to a proper strength by adding the necessary KCy.

The cost of the Siemens-Halske process is slightly greater than that of zinc precipitation, and the percentage of extraction is about the same. But the Siemens-Halske process may be applied to any solution, weak or strong.

A digest covering most of the patents issued by the United States Patent Office in certain of the subclasses of metallurgy, and subclass 15 of electrolysis, up to 1904, is given in the Appendix.

Scope.—From the description of its mode of operation it is evident that the "straight cyanide process" is readily applicable to free milling ores which are free from mineral substances that would foul the solution or consume the cyanogen salt, and the gold in which is finely divided and so exposed that the cyanide solution may come in intimate contact with it. In old tailings which have been exposed for years to the action of the weather, whereby the sulphurets have been oxidized and the acids and salts formed, dissolved and washed away, there has been found much material ready at hand for immediate treatment in the simplest manner. The problem is comparatively simple, also, in the case of siliceous gold bearing deposits free from sulphurets, but the ore must be crushed, and in many instances it is more economical to concentrate it than to expose the entire mass to the action of the cyanide solution. Moreover, even in the case of neutral and otherwise suitable ores, the fine particles of metallic gold may be so enveloped in an impermeable covering—such as iron or aluminum hydroxide—as to necessitate a preliminary treatment, such as roasting, to rupture the envelope. An example of this kind is found in the ores of the Republic gold mine, Washington, described by T. M. Chatard and Cabell Whitehead.[1] When coarse gold is mingled with the fine, it is usually more economical to separate the coarse gold by amalgamation than to await the slow-acting process of solution. With tailings in which the sulphurets are but partly decomposed and which still contain ferrous and ferric salts and sulphuric acid, cyaniding may be preceded by washing and neutralization.

The treatment of refractory ores is determined, in each case, by the chemical and physical characteristics of the ore under consideration. Hence, we find that cyaniding may be combined not only with crushing, roasting, concentration, and amalgamation, but also with smelting and chlorination. In some instances it is most advantageous to separate the ore into fractions, each of which is subjected to a different treatment. In fact, it is essential to success that the ore should be thoroughly examined by a competent metallurgical chemist before any investment in a plant for treatment

[1] Transactions of the American Institute of Mining Engineers, Vol. XXX, pages 419 to 423.

by chemical processes is made, and also that the cyaniding process should be under chemical supervision, in order that, by assays of the ore and tailings and by analyses of the ore and the cyanide solutions as they enter and issue from the zinc boxes, and of the solvent during preparation and regeneration, a complete check may be made upon the operation in each of its stages.

Working costs.—It is obvious that the cost of the cyanide process will vary at the different plants, according to the variations in the chemical composition and physical structure of the ore treated, in the condition of the ore at the time of treatment—that is, whether it be in the form of sand or slimes—in the character of the process and the apparatus used; in the location of the mill with regard to the supply of ore or tailings used; and the source of power, water, materials, and labor. According to H. M. Chance,[1] in the Black Hills, S. Dak., the cost of smelting siliceous ores was between $4.75 and $5.75 per ton; the cost of chlorination, from $3.50 to $4.50 per ton; and the cost of the cyanide treatment, possibly from $3 to $3.75 per ton. From the Report of the Director of the Mint, for the calendar year 1901,[2] it appears that in that year there were 11 cyanide plants in active operation in South Dakota, having a united capacity of over 1,500 tons daily, and that some of these mills claim to be able to treat ore at a cost not exceeding 80 cents per ton, though the average cost is probably nearer $1.50 per ton. Julian and Smart[3] give 21 different detailed accounts of costs at mines in Australia, Africa, and the United States, the results ranging from 2s. 1.23d. per ton by the Siemens process, in South Africa, to 17s. 1.02d. per ton by the Diehl process, in Western Australia.

Effect on the world's supply of the precious metals.—The data collected at this census deal only with the output of the United States for 1902. There are no collected data to afford a comparison of the condition of this industry in that year with the condition during any previous period since its introduction into this country, in 1891. But the consensus of evidence, as presented in current literature, indicates that the industry has been constantly growing, that new plants are going up each year, and that established ones are increasing their capacity. This is true not only of the United States, but also of Africa, Australia, New Zealand, Mexico, and the other gold producing countries; from each are coming increased supplies of the precious metals extracted from low-grade ores and tailings.

[1] Transactions of the American Institute of Mining Engineers, Vol. XXX, pages 278 to 282.
[2] Production of the Precious Metals during 1901, page 201: 1902.
[3] Cyaniding Gold and Silver Ores, 1904, pages 372 to 381.

CALENDAR OF EVENTS AND DISCOVERIES RELATIVE TO THE PRECIOUS METALS.

1530–1540. Pillage of Peru.
1547–1548. Discovery of Guanajuato silver mines in Mexico.
1577. Discovery of gold in Brazil.
1670. Discovery of placers of Garazua.
1680. Discovery of placers of Minas-Geraes.
1704–1728. Silver mines opened in Russia.
1743. Discovery of gold in the Ural.
1848. Discovery of placers in California.
1848. Introduction of Plattner's chlorination process at Reichenstein in Silesia.
1851. Discovery of placers in Australia.
1853. Introduction of hydraulic mining in California.
1853. Maximum annual production of gold in California, amounting to $65,000,000 for the year.
1858. Introduction of chlorination process at Grass Valley, California.
1866. Invention of dynamite.
1886. Opening of the "banket" reef of the Rand, South Africa.
1889. Development of Manké's method of bessemerizing copper mattes, and the successful refining of this impure copper by electricity.
1890. Introduction of the cyanide process in the Rand, South Africa.
1897. Discovery of placers in the Yukon.

Apart from the phenomenal annual increase in the production of gold during the period from 1841 to 1855, which includes the discoveries of the rich placers of California and Australia, the increase in the world's production during the last decade of the nineteenth century was unprecedented. It was most marked during the period from 1891 to 1895, following the opening of the "banket" reef of the Rand and the introduction of the cyanide processes, but it was continuous throughout the decade, except during the period of the Boer War, and the output of gold in 1902 exceeded that of any other year of our record except 1899. It is true that the use of the cyanide process is only one of several causes contributing to this result, but that it is an important one is indicated by the fact that the returns for this census show that the amount of gold recovered by the use of the cyanide process in the United States in 1902 exceeded that won throughout the whole world by all existing means during any year of our record up to 1661, and probably up to 1701.

LITERATURE.

The Art of Electro-metallurgy, by G. GORE: D. Appleton & Co., New York: 1877.

The MacArthur-Forrest Process of Gold Extraction, by J. S. MACARTHUR: Journal of the Society of Chemical Industry, Vol. 9, pages 267 to 271: 1890.

The Cyanide Process for the Extraction of Gold from Low-Grade Gold Ores, by T. GRAHAM YOUNG and WATSON SMITH: Journal of the Society of Chemical Industry, Vol. 10, pages 93 to 98: 1891.

The Mineral Industry, Vol. 1–Vol. 12: 1892–1903.

The Dissolution of Gold in a Solution of Potassium Cyanide, by R. C. MACLAURIN: Journal of the Chemical Society, Vol. 63, pages 724 to 738: 1893.

Annual Reports of the Director of the Mint on Production of the Precious Metals, 1894 to 1903: Government Printing Office, Washington.

The Cyanide Process, its Practical Application and Economical Results, by A. SCHEIDEL: Bulletin No. 5 of the California State Mining Bureau: 1894.

Cyanide Processes, by E. B. WILSON: J. Wiley & Sons, New York: 1896.

The Metallurgy of Gold, by M. EISSLER: Crosby, Lockwood & Son, London, 678 pages: 1896.

The Cyanide Process of Gold Extraction, by JAMES PARK: E. & F. N. Spon, London: 1897.

The Cyanide Process in the United States, by GEORGE A. PACKARD: Transactions of the American Institute of Mining Engineers, Vol. XXVI, pages 709 to 721: 1897.

Laboratory Tests in Connection with the Extraction of Gold from Ores by the Cyanide Process, by H. VAN F. FURMAN: Transactions of the American Institute of Mining Engineers, Vol. XXVI, pages 721 to 734: 1897.

The Solution and Precipitation of the Cyanide of Gold, by S. B. CHRISTY: Transactions of the American Institute of Mining Engineers, Vol. XXVI, pages 735 to 772: 1897.

The Metallurgy of Gold, by T. KIRKE ROSE: Charles Griffin & Co., London: 1898.

The Precipitation of Gold by Zinc Thread from Dilute and Foul Cyanide Solutions, by ALFRED JAMES: Transactions of the American Institute of Mining Engineers, Vol. XXVII, pages 278 to 283: 1898.

A Handbook of Practical Cyanide Operations, by W. H. GAZE: G. Robertson & Co., London: 1898.

The Cyanide Process for the Extraction of Gold, by M. EISSLER: Crosby, Lockwood & Son, London: 1898.

The Cyanide Process—a discussion: Transactions of the American Institute of Mining Engineers, Vol. XXVII, pages 821 to 846: 1898.

Cyaniding in New Zealand, by JAMES PARK: Transactions of the American Institute of Mining Engineers, Vol. XXIX, pages 666 to 681: 1900.

Notes on the Aurex Sluice, by T. M. CHATARD and CABELL WHITEHEAD: Engineering and Mining Journal, Vol. LXIX, pages 138 to 140: 1900.

An Examination of the Ores of the Republic Gold Mine, Washington, by T. M. CHATARD and CABELL WHITEHEAD: Transactions of the American Institute of Mining Engineers, Vol. XXX, pages 419 to 423: 1901.

Cyanide Practice, by ALFRED JAMES: Engineering and Mining Journal, New York: 1902.

Gold Mining in the Transvaal, South Africa, by JOHN HAYS HAMMOND: Transactions of the American Institute of Mining Engineers, Vol. XXXI, pages 817 to 855: 1902.

The Delamar and the Horn Silver Mines: Two Types of Ore Deposits in the Deserts of Nevada and Utah, by S. F. EMMONS: Transactions of the American Institute of Mining Engineers, Vol. XXXI, pages 658 to 683: 1902.

Cyaniding Gold and Silver Ores, by H. F. JULIAN and E. SMART: Charles Griffin & Co., London: 1904.

APPENDIX.

DIGEST OF UNITED STATES PATENTS RELATING TO CYANIDE PROCESSES FOR THE RECOVERY OF PRECIOUS METALS.

This digest covers most of the patents included in the following classes and subclasses of the United States Patent Office classification:

Class 75.—Metallurgy.
- Subclass 18.—Solutions and Precipitation.
- Subclass 86.—Solutions and Precipitation—Apparatus.
- Subclass 185.—Cyanides.

Class 204.—Electrolysis.
- Subclass 15.—Aqueous Bath, Ores.

Some of the patents in these categories are quite foreign to the subject under consideration, and many but indirectly related to it. It has been thought, however, from the form which discussions of patent issues often take, to include the latter. The aim in making the digest has been to give such a sketch as will indicate the nature of the invention and what is claimed by the inventor, this generally being done by an actual abstract from or paraphrase of the words of the letters patent, but no responsibility is assumed for the opinions, theories, or claims thus set forth. Other related patents may have been granted which do not appear in this digest, because they are not embraced in the subclasses enumerated. Thus, the patents number 229586, to Thomas C. Clark; 236424, to H. W. Faucett; and 244080, to John F. Sanders, do not appear in this digest, because the first two are classified under subclass "Reducing and Separating—Disintegrating Ores," and the third under subclass "Reducing and Separating—Gold and Silver," and neither of these subclasses is included in this digest.

CLASS 75.—METALLURGY.

Subclass 18.—Solutions and Precipitation.

15542—August 12, 1856. W. Ziervogel. *Improvement in processes of separating silver from the ore.*

The application of water or a solution of sulphate of copper slightly impregnated with sulphuric acid instead of lead, quicksilver, or salt, hitherto used for this purpose, to the process of separating silver from copper and other ores, rendering thereby this separation easier, shorter, less expensive, and not noxious to the health of the operator.

19991—April 20, 1858. I. Gattman. *Improvement in the treatment of sulphureted ores.*

The use of sulphuric acid in connection with the hydrate, carbonate, or sulphate of potash or soda, or with any compound thereof, in the mode of working the native metallic sulphurets.

35842—July 8, 1862. J. Shaw. *Improved apparatus for saving silver from waste solutions.*

Attaching to the waste pipe of the sink or basin into which persons using silver in solutions suffer them to be wasted, a vessel so arranged and constructed that the liquids passing from the sink shall run into, through, and out of said vessel, and between the time of entering said vessel and escaping therefrom shall be brought into contact with such chemicals or metals as will cause the whole or any part of the silver contained in solution to be precipitated and retained in said vessel, while the worthless material is allowed to escape. (This patent was reissued as follows: Reissue 1651, April 5, 1864; reissue 3506, June 15, 1869; reissue 4030, June 14, 1870; reissue 4969, Division A, July 9, 1872; and reissue 4970, Division B, July 9, 1872.)

46875—March 21, 1865. W. Brückner. *Improved process for refining amalgam.*

The application and use of bichloride of copper, or its equivalent, together with iron pyrites and salt, without reference to the exact proportions of each ingredient.

46983—March 28, 1865. G. W. Baker. *Improvement in treating ores.*

In order to produce a valuable metal or metals now almost wholly cast away in the treatment of auriferous and argentiferous pyrites, the inventor proposes to take the calcined ores as they come from the furnaces, and, having them well pulverized, subject them to the action of sulphurous acid in tanks located over the main discharge flues of his furnaces, whereby a sufficient heat may be obtained to assist in the reaction of the acid before mentioned. The sulphurous acid thus used is to be formed and collected by compelling the sulphurous vapors discharged from the roasting furnace to pass over, through, and in contact with water, so that sulphurous acid will be formed and collected in a properly arranged tank or tanks, from whence it may be conveyed to the ore tanks, and there mixed with the ore thoroughly by agitation in any manner most convenient. After the ore has been subjected to the action of the acid for a couple of hours the oxide of copper will be replaced by a sulphate soluble in water, and the oxide of iron will be partially brought into the same condition. Should there be any gold or silver held in solution these metals will be reduced to the metallic state. The solution is then drawn off by siphon or otherwise and conveyed to another tank or vat for subsequent treatment, either by cementation or precipitation for the copper and evaporation for the sulphate of iron. The ore thus treated may then be lixiviated by water to wash out all the acid, and this water, which will still hold some dilute solution of the baser metals, may be conveyed to the acid tank and used for the further formation of sulphurous acid. By this means the most concentrated solution is alone permitted to pass to the tank or vat for further treatment. It may be considered a well-settled fact that in all processes of calcination some portion of the precious metals, if such ores are under treatment, escape mechanically or in a vaporized form. This loss, great or small, as the case may be, has heretofore been to a great degree irreclaimable. It is claimed as a part of this improvement that such loss, whether mechanical or in the form of vapor, is wholly prevented by arresting their escape and returning them, either in solution or in the sediment of the liquid acid, to the ore when treated in the ore tanks.

47286—April 18, 1865. W. L. FABER. *Improved process of working silver ores.*

The invention consists in a process which is divided in eight different manipulations, viz, smelting the ore, pulverizing, roasting at low heat, extracting sulphates with water, roasting residue with salt, melting with soda, precipitating silver, precipitating copper.

49637—August 29, 1865. S. F. MACKIE. *Improved process for treating ores.*

The mode of obtaining a rich gold residue from ores of gold by treating the ores by roasting and fusing, and subjecting the roast to the action of acids.

52834—February 27, 1866. J. H. ELWARD and J. L. HAYES. *Improved process for separating gold and silver from ores.*

The process of oxidizing sulphurets containing the precious metals and converting them into sulphates by the use of solutions of nitrates.

56765—July 31, 1866. E. LAMM. *Improved method of preparing gold for dentists.*

The use of saccharine substances to precipitate gold from its solutions, thereby forming a mass of crystal shreds extremely useful and convenient for dental and other purposes.

148356—March 10, 1874. J. DOUGLAS, Jr. *Improvement in extracting silver from its ores.*

The process of utilizing the waste liquors of the ordinary ore-chloridizing process, by allowing the insoluble matters contained in said liquors to precipitate, and then evaporating the clear supernatant liquid to obtain the soluble chlorides, which are reapplied in treating fresh ore.

207695—September 3, 1878. J. TUNBRIDGE. *Improvement in separating metals from waste solutions.*

The process of separating precious metals from watery solutions, in which said metals are suspended by passing the watery solutions or suds through a bath of oil or hydrocarbon liquid.

219961—September 23, 1879. F. M. LYTE. *Improvement in extracting metals from ores.*

In the treatment of ores containing lead, zinc, silver, and copper, the method of securing the neutralization of the solutions of soluble bases, economizing acid, and carrying over the least possible quantity of silver and lead, which consists in treating the raw ores with an acid solution partially saturated by previous attack on the ores, and treating the partially exhausted ore by raw acid before the latter is admitted to the raw ore, the said steps being conducted in a continuous, alternate, and methodical manner.

227963—May 25, 1880. W. M. DAVIS. *Depositing gold from its solutions.*

The process of obtaining gold from its solution by bringing said solution in contact with carbon, and thereby depositing the gold upon it, and of subsequently obtaining the gold from the carbon by calcination or other equivalent means.

287737—October 30, 1883. C. A. STETEFELDT. *Process of treating sulphides.*

The process of treating sulphides, such as those obtained from the lixiviation process of silver ores, said process consisting in first exposing said sulphides to the action of dilute sulphuric acid in the presence of nitrate of soda, then converting the nitric oxide which escapes into nitrous acid and nitric acid, and finally carrying on the process by means of a mixture of nitrous acid and nitric acid with dilute sulphuric acid.

288838—November 20, 1883. J. MILLER. *Process of recovering metallic particles from water.*

The method of recovering metals in suspension in liquid, consisting, essentially, in forcing such liquid through a filtering medium having a capacity of expansion, and resisted by a rigid inclosing vessel or medium, and then burning the filling material or otherwise separating the metal therefrom.

290258—December 18, 1883. J. MILLER. *Apparatus for collecting and saving metallic particles.*

An apparatus for recovering metals or metallic compounds in liquids, consisting of a rigid tank, perforated on one side, in combination with an entrance pipe, provided with a trap and a pressure device.

290458—December 18, 1883. J. MILLER. *Method of recovering metals.*

The improved method for recovering metallic particles, slimes, and similar material containing metal from liquids, consisting, essentially, in conducting the liquid and metal bearing material to a settling tank, allowing the gangue to fall to the bottom, drawing off the liquid, and forcing it under hydrostatic pressure through a filter press, and removing and drying the filtrate.

292605—January 29, 1884. C. P. WILLIAMS. *Art of extracting gold by means of alkaline sulphides.*

In the art of extracting gold from ores and artificial gold bearing products by means of alkaline sulphides, the process, which consists in mixing the gold bearing material with carbon and an alkaline sulphate (or the equivalents of such carbon and alkaline sulphate), calcining said mixture in a nonoxidizing atmosphere at a temperature below the point of fusion of the charge, cooling the mass out of contact with the air, and leaching the cooled mass with water to dissolve out the soluble sulphides, and recovering the gold therefrom by precipitation.

377809—February 14, 1888. T. KIDDIE. *Process of separating precious metals and impurities from solutions of copper, salts, ores, mattes, etc., in acids.*

The process of removing precious metals and impurities from copper mattes, ores, bullion, etc., consisting in dissolving the same after desulphurization and calcination in sulphuric acid, in quantities sufficient to form a neutral solution, and in adding iron hydrates to the neutral solution, whereby the impurities are precipitated and settle with the precious metals not dissolved by the sulphuric acid, leaving a comparatively pure solution of iron and copper salts.

381809—April 24, 1888. R. OXLAND and C. OXLAND. *Treatment of ores and materials containing sulphur for the extraction of metals and other constituents.*

The method of treating raw or unburned sulphuret ores of copper and iron to render the copper soluble in water, while leaving the iron for the most part insoluble and rendering the sulphur in the ore available for the manufacture of sulphuric acid, consisting in mixing the finely pulverized ore to a semifluid consistency with sulphuric acid and solution of persulphate of iron, heating the mixture to a temperature such as to evolve sulphurous-acid vapor, and collecting and condensing such acid vapor.

387688—August 14, 1888. A. H. LOW. *Extraction of zinc from ores.*

The process of extracting zinc from ores containing precious metals, consisting in leaching the ore with an aqueous solution of sulphurous-acid gas to dissolve out the zinc, and then boiling the leached liquor to expel the sulphurous-acid gas and cause a precipitation of the zinc.

403615—May 21, 1889. E. H. RUSSELL. *Process of leaching ores with hyposulphite solutions.*

The process of extracting metal from ores and metallurgical products, which consists in introducing into the ore or product carbonate of soda, then treating the mass with a solution of sulphate of copper, and then treating it with a hyposulphite solution.

413808—October 29, 1889. J. S. MACARTHUR. *Process of leaching ores.*

The process of treating ores containing oxides or carbonates of earth metals, consisting in first subjecting such ores to the action of a proportionate quantity of a solution of a ferrous salt or a bisulphate of an alkali to combine with the oxides or carbonates of earth metals, and then treating the ores with an acid or salt to obtain the contained metals.

421031—February 11, 1890. R. PEARCE. *Process of extracting silver from copper ores, mattes, and other copper products.*

The process of separating silver from ores or mattes containing base metals, which consists in mixing with the finely pulverized ore or mattes a quantity of sulphate of sodium or potassium equal to 2 per cent, then roasting the mixture, and finally leaching out by hot water to obtain the sulphate of silver.

440143—November 11, 1890. E. DODE. *Process of separating gold and platinum from other metals in solution.*

The process of separating from an acid solution of gold, platinum, copper, and tin the metallic constituents of said solution, which process consists in first subjecting the entire solution in the presence of ether to agitation until the ether becomes yellow, in then decanting the remaining solution from the yellow ether, in then subjecting said remaining solution to agitation in the presence of essence of lavender until the essential oil becomes brown, and in then decanting from the brown essential oil the remaining solution and adding thereto ammonia.

442016—December 2, 1890. C. L. COFFIN. *Process of treating ore containing lead, silver, and zinc.*

The process of treating ore containing lead, silver, and zinc to remove the zinc preparatory to smelting, consisting in first roasting the ore, then leaching the ore, filtering the leach fluid through carbon, then subjecting the leach fluid successively to the action of metallic lead and of metallic zinc, and finally precipitating the zinc held in solution in the leaching fluid.

444997—January 20, 1891. W. WEST. *Process of treating zinc ores.*

The process of eliminating zinc from complex ores, which consists in roasting the ore to form sulphurous-acid gas and oxidize the zinc, then cooling this gas to a temperature of 180° F. or below, and passing the same in gaseous form in conjunction with steam and without oxidation into sulphuric acid through a previously roasted charge to form soluble sulphite of zinc, and then immediately leaching out and separating the zinc sulphite with water at a temperature below 180° F.

449814—April 7, 1891. S. W. CRAGG. *Lixiviation process of and apparatus for the extraction of gold or silver.*

The process of restoring the oxygen in a hyposulphite solution in the lixiviation process, which consists in passing a current of air through the ore pulp while the said solution is in contact therewith, and a leaching vat, a grating at the top thereof through which ore pulp and water are introduced to the interior of the vat, and a system of crossed separated bars within the vat through which the ore pulp and water pass, combined with an endless-apron filter on which the ore pulp and water fall from the said crossed bars, a trough beneath the filter to receive the water, and a lixiviation vat into which the apron filter discharges the ore pulp.

471616—March 29, 1892. J. LEEDE. *Process of treating refractory ores.*

The continuous process of treating refractory auriferous and argentiferous ores, which consists in subjecting the ore to the continuous action of an oxidizing blowpipe flame in direct contact with the ore at a moderate heat, intermittently subjecting the heated ore to the action of water, agitating the ore, and then repeating the operation at a higher heat, and finally subjecting it to an oxidizing roast without chills, whereby the volatile elements are driven off, the oxidizable elements or compounds are oxidized, and the precious metals are left free and in suitable condition for amalgamation or chlorination.

473186—April 19, 1892. P. C. CHOATE. *Method of producing metallic zinc.*

The process of producing metallic zinc from its ores, which consists in separating the zinc and the equally volatile and more volatile constituents from the less volatile constituents of the ore by the use of heat and a reducing agent, then volatilizing and oxidizing the reduced metal, thereby obtaining a condensed oxidized fume, subjecting this fume to a moderate heat in order to expel its soluble constituents more volatile than zinc, treating the remaining product with dilute sulphuric acid as a solvent, and finally subjecting the resulting solution to the action of an electric current to precipitate the zinc.

481499—August 23, 1892. G. T. LEWIS and C. V. PETRAEUS. *Process of treating sulphide ores of zinc and lead.*

The process of recovering lead and zinc from sulphureted lead and zinc-lead ore, which consists in roasting the ore, then smelting the roasted mass and exposing the fumes or volatile matter produced by said smelting to the action of the gases which are volatilized in the roasting of said ore, together with water, and then separating the zinc solution from the insoluble lead compound and recovering the zinc and lead.

483924—October 4, 1892. T. S. HUNT and J. DOUGLAS. *Process of separating copper from cupriferous nickel ores.*

The method of separating the copper from a solution containing copper oxide and oxides of iron and nickel to produce nickeliferous iron, which consists in first adding common salt to the said solution, then passing a stream of sulphurous acid gas through the said solution, then precipitating the last traces of the copper in the form of metallic copper, and subsequently crystallizing out the nickel and iron and calcining and smelting the product to obtain nickeliferous iron.

483972—October 4, 1892. C. WHITEHEAD. *Process of treating mixtures containing sulphides of precious metals and copper.*

The process of treating a mixture containing sulphides of the precious metals and of copper, which consists in mixing the sulphides with solution of a salt of silver, whereby a soluble salt of copper is formed and sulphide of silver is precipitated, separating the solution containing the copper from the residue containing the precious metals, roasting this residue to reduce the precious metals to the metallic state, treating the reduced metals with hot sulphuric acid to dissolve the silver, separating the silver solution from the residue, and melting the final residue.

490068—January 17, 1893. F. P. DEWEY. *Process of treating mixtures containing sulphides.*

The process of treating mixtures containing sulphides of silver and copper, which consists in heating the sulphides with strong sulphuric acid to convert the sulphides into sulphates and dissolve the sulphate of silver, adding water, to bring the sulphate of copper also into solution, drawing off the resultant solution, precipitating the silver therefrom by metallic copper, and recovering the sulphate of copper from the remaining solution.

490193—January 17, 1893. A. FRENCH. *Process of obtaining gold, silver, and copper from ores.*

In processes for obtaining gold, silver, and copper from ores, the treatment of the ores by pulverizing, mixing therewith small percentages of niter cake or bisulphate of soda and common salt, furnacing at a red heat, and then leaching.

497473—May 16, 1893. W. R. INGALLS and F. WYATT. *Process of treating complex or sulphide ores.*

The process of treating complex sulphide ores, which consists, first, in subjecting the ore to a sulphatizing roasting; second, lixiviating the roasted ore with water and sulphuric acid and removing the iron therefrom if necessary; third, precipitating the zinc from said solution in the form of carbonate or carbonate and hydroxide by the use of sodium carbonate and subsequently converting the same into zinc oxide; fourth, evaporating the sodium sulphate obtained from the zinc sulphate solution and heating the same with sodium chloride and coal to convert it into sodium sulphide; fifth, converting the sodium sulphide into bicarbonate of soda by dissolving the same in water and treating the solution with carbonic acid gas; and lastly, converting the bicarbonate of soda into sodium carbonate by heating the same to drive off the hydrogen and carbonic acid gas.

509058—November 21, 1893. E. Waller and C. A. Sniffin. *Method of concentrating ores.*

The method of concentrating argentiferous lead carbonate ores, which consists in dissolving out lead from the ore with the aid of acetic acid, real or combined, and water, out of contact with the air whereby the lead and carbonic acid eliminated from the ore are rendered capable of utilization in the arts, and the undissolved silver is concentrated in the residue.

509633—November 28, 1893. D. K. Tuttle and C. Whitehead. *Process of treating precious metal bearing slimes.*

The process of treating precious metal bearing slimes, which consists in subjecting the slimes to the action of dilute acids to dissolve the metals and oxides soluble therein and to the action of a solution of a salt of silver to remove metals more electro-positive than silver that are present in the metallic state.

509634—November 28, 1893. D. K. Tuttle and C. Whitehead. *Process of refining slimes from the electrolytic refining of copper.*

The process of treating slimes from the electrolytic process of refining copper, which consists in removing arsenic, antimony, tellurium, bismuth, and other impurities present as oxides by treating the slimes with dilute acid and heating the purified slimes with strong hydric sulphate.

513490—January 30, 1894. S. H. Emmens. *Process of treating zinc-lead-sulphide ores.*

The process of treating zinc-lead-sulphide ores carrying gold or silver or gold and silver, which said process consists in, first, finely comminuting the ore; secondly, roasting the same in an oxidizing atmosphere; thirdly, leaching such roasted ore with water containing ferrous sulphate; fourthly, leaching such once leached ore with an aqueous solution of ferrous and ferric sulphates; fifthly, leaching such twice leached ore with water containing ferrous sulphate; and sixthly, removing iron from the zinc sulphate solution obtained by the first and second of the said leachings by mixing such solutions together and heating them.

516016—March 6, 1894. W. R. Ingalls and F. Wyatt. *Treatment of ores of zinc.*

The process of treating ores of zinc, which consists, first, in subjecting the ore to an oxidizing roasting; second, lixiviating the roasted ore with water and sulphuric acid; third, separating one-fourth of the zinc-sulphate solution thereby formed from the rest and precipitating the zinc from said separated portion by means of a sulphide of an alkaline base; fourth, evaporating the remainder of the zinc-sulphate solution to dryness and mixing the precipitated sulphide therewith; and lastly, heating the mixture in a suitable furnace whereby sulphurous anhydride gas is evolved.

518890—April 24, 1894. L. Klöz. *Process of extracting zinc from ores.*

The process of treating zinc ores, which consists, first, in the preparation of a concentrated solution of sulphurous acid; second, in leaching the ores or furnace products with this solution to form a concentrated zinc sulphite solution free from sulphates; and third, scattering this solution by steam to dispel the sulphurous acid and precipitate the zinc sulphite.

527473—October 16, 1894. P. Argall. *Cyanide and chlorination process for treating gold or silver bearing ores.*

In the process of preparing gold and silver bearing ores for the extraction of the precious metals, the improvement consisting in separating the slime from the granulated ore, preventing the forming of acid in the slime by mixing lime therewith, and then forming the mixture into lumps for burning.

541374—June 18, 1895. E. B. Mierisch. *Process of extracting gold and silver from their ores.*

The process of extracting gold and silver from oxidated or roasted ores, which consists in mixing the ground ores with sodium hydrate, mixed with a corresponding quantity of calcium hydrate, then subjecting the mixture to the action of chlorine, whereby the ores are acted upon by chlorates, and hydrochlorites formed "in statu nascendi," and then leaching the lye with a concentrated sodium-chloride solution, the deterioration of which is prevented by the addition of the calcium hydrate to the sodium hydrate.

541447—June 18, 1895. H. F. Watts and A. Coan. *Process of reducing zinc slimes.*

The process of treating zinc slimes containing the precious metals, which consists in first treating the same with dilute sulphuric acid for the purpose of removing metallic zinc, washing the residue to remove the soluble salts and the remaining acid, and boiling the residue thus formed with concentrated sulphuric acid to dissolve the cyanide of zinc and the other salts thereof which are insoluble in the dilute acid.

541659—June 25, 1895. J. J. Crooke. *Process of and apparatus for extracting silver from its ores.*

The process of extracting silver from its ores, which consists in roasting the ores with chloride of sodium, treating the roasted mass with a hot aqueous solution containing chloride of sodium, nitrate of copper, and sulphuric acid, and recovering the silver from the solution.

544493—August 13, 1895. H. Brewer. *Process of utilizing waste lye.*

The process of treating zinciferous or cupriferous lyes resulting from the lixiviation of chlorinated roasted ores, which consists in chemically extracting the metals in the lye, except the zinc, removing the sodium chloride by concentration of the lye, extracting the zinc and chlorine from the remaining lye electrolytically, and effecting the chemical extraction in such manner that the final lye will consist essentially of a solution of calcium chloride.

544612—August 13, 1895. A. Crossley. *Process of manufacturing zinc.*

The process for the manufacture of zinc oxide, which consists in adding sulphuric acid to the metallic ores or compounds, heating the mixture and converting the lead present to an insoluble salt, and depositing any silver or gold present, then diluting with water and converting the other metals present to soluble salts, filtering off the clear liquor, then treating the clear acid liquor filtered off with an alkaline sulphide, precipitating the copper as copper sulphide, then filtering the liquor from the precipitate, treating with an alkali until neutral, passing chlorine into it until all manganese and iron present form manganic and ferric oxides, which are thrown down by a slight excess of alkali, adding an excess of alkali to bring the zinc oxide into solution, and then precipitating the zinc oxide, and filtering off the liquor therefrom.

547587—October 8, 1895. C. V. Petraeus. *Method of extracting zinc from complex ores.*

The method of separating zinc from complex ores where it is found as a sulphate or sulphite, which consists in crushing the ore, roasting it, dissolving out the soluble zinc salts in water, adding a solution of sulphuric acid to dissolve out any zinc oxide, introducing live steam to the mixture of ore and solvents to thoroughly mix and heat them, separating the solution of sulphate of zinc from the insoluble parts of the ore, adding chloride of calcium to the solution to convert the zinc into a chloride, separating the solution of zinc chloride from the precipitated calcium sulphate and finally adding quicklime to the solution of zinc chloride to precipitate the zinc as zinc oxide.

556690—March 17, 1896. G. O. PEARCE. *Process of extracting gold from solutions.*

The process of recovering gold and platinum metals from aqueous solutions of these metals, which consists in passing said solutions through a mass of vegetable carbon having associated with it sulphate of iron, oxalic acid, and tartaric acid.

559614—May 5, 1896. G. A. SCHROTER. *Extraction of precious metals.*

The process of extracting precious metals, particularly silver, from ores and metallurgical products, which consists in leaching the crushed and chloridized ore with a concentrated solution of brine to which has been added a small per cent (one-half to 4 per cent approximately) of a soluble salt of copper.

561544—June 2, 1896. F. P. DEWEY. *Process of treating sulphides.*

The process of treating mixtures containing sulphides of silver and copper, which consists in heating the mixture with strong sulphuric acid, adding water, adding more mixed sulphides, separating the solution of sulphate of copper from the residue containing the sulphide of silver, and heating the sulphide of silver with strong sulphuric acid to convert it into sulphate.

561571—June 9, 1896. F. P. DEWEY. *Process of treating mixtures containing sulphides.*

The process of treating mixtures containing sulphides of silver and copper, which consists in heating them to a temperature at which the sulphur is oxidized, in an excess of sulphuric acid sufficient to convert the sulphides of silver and copper into sulphates, and bring the sulphate of silver into solution outside of the mass of material treated, thereby oxidizing the sulphur, converting the sulphides into sulphates, and bringing the sulphate of silver into solution in the acid outside of the mass of material acted upon.

571369—November 17, 1896. B. HUNT. *Process of refining gold and silver bullion.*

The process of refining bullion slimes by first roasting the slimes to decompose all cyanogen compounds and carbonaceous matters and then treating the roasted slimes with nitric acid.

586159—July 13, 1897. H. BREWER. *Process of treating zinc sulphide ores.*

In a process of treating zinciferous sulphate lyes resulting from the lixiviation of chlorinated roasted zinc sulphide ores, adding sodium chloride to such lye to saturation or in excess, and crystallizing out the resulting sodium sulphate (Glauber salt) by refrigeration as a by-product.

587128—July 27, 1897. E. F. TURNER. *Process of treating argentiferous sulphide ores.*

In a process for the extraction of the metal of compound sulphide ores, disintegrating and decomposing the latter by the combined action of aqueous and gaseous hydrochloric acid, neutralizing the acid gases evolved whereby sulphureted hydrogen is obtained, heating the disintegrated ore by means of such sulphureted hydrogen, collecting the sulphur dioxide resulting from the combustion, bringing this gas into contact with sodium chloride in presence of heat, whereby hydrochloric acid gas and sodium sulphate are obtained, and utilizing the former in the process of disintegration.

588476—August 17, 1897. H. A. RHODES. *Process of separating gold and silver or other precious metals from their ores.*

In chemical processes for the separation of gold or other precious metals from their ores, slimes, or compounds, the method of preparing the ores by adding thereto a self hardening, binding material and forming a porous and rigid mass of the compound whereby the precious metals contained therein are freely acted upon by the solvent.

589959—September 14, 1897. J. J. CROOKE. *Process of treating copper sulphides.*

The process of recovering silver or gold and extracting copper in a metallic condition from copper sulphides associated with iron sulphides, which consists in roasting the pulverized sulphides with sodium chloride at a low heat, leaching the roasted mass with a solution whereby the iron sulphides are largely converted into oxides and the silver and gold are dissolved by and removed with the solution, recovering the silver and gold from the solution, roasting the residuum or tailings, fluxing the roasted tailings with silica and pulverized carbon, gradually melting the roasted and fluxed charge to convert the oxide of iron into metallic iron and desulphurize the copper sulphides to liberate metallic copper and form an iron silicate slag, removing the slag from the melted copper, adding a small per centum of silica to convert any remaining iron oxide or metallic iron into an iron silicate slag, and removing this slag from the copper.

602295—April 12, 1898. E. A. ASHCROFT. *Treating solutions or ores containing zinc for recovering zinc as oxides.*

The process of treating neutral zinc solutions for the production of zinc oxide, which consists in first converting the neutral zinc salt into basic zinc salt by the addition of zinc oxide and then intimately mixing with said basic zinc salt, carbon in approximately the proportion of one-twentieth of the weight of the zinc to be recovered, and heating the mixture to a temperature approximating the melting point of aluminum.

623154—April 18, 1899. H. HOWARD. *Extraction of zinc and copper from ores.*

The process of extracting zinc and copper from ore or residue, which consists in treating the same with aqua ammonia and ammonium sulphate; separating the copper from the resulting solution; adding sufficient soda to combine with all of the sulphuric oxide present and form sulphate of soda, and evaporating the solution to drive off ammonia, the latter being collected in water; and treating the residue with water to dissolve out the sulphate of soda, the zinc oxide remaining.

624000—May 2, 1899. J. DURIE. *Method of reducing metallic sulphides.*

In the process of causing the solution of metallic sulphides containing lead, subjecting the sulphide ore to a solution of sulphuric acid and a nitrate of an alkali metal at a temperature of about 212° Fahrenheit, washing and filtering the lead sulphate obtained therefrom, dissolving the said sulphate, precipitating by carbon dioxide, washing and drying the precipitated hydrated carbonate of lead, and recovering the sulphur.

625433—May 23, 1899. M. BODY. *Process of treating sulphureted ores.*

In the process of treating sulphureted ores of a complex nature, comminuting and melting the ore in presence of an alkaline salt and carbon, whereby alkaline polysulphides soluble in water are formed, plunging the melted mass into water, whereby a magnetic precipitate is formed and the polysulphides dissolved in the water, separating the solution from the precipitate, subjecting the same to the action of air and sulphurous-acid gas forced thereinto, whereby monosulphides of iron, together with the precious metals, are precipitated, maintaining the alkalinity of the solution during the operation of precipitation by addition of an alkaline substance, as lime, separating the solution from the monosulphide-of-iron precipitate, extracting from the latter the copper and then the precious metal, and separating the arsenic and antimony from the solution by precipitation.

627024—June 13, 1899. R. THRELFALL. *Method of treating flue dust and fume obtained from sulphide ores.*

In the treatment of flue dust and fume from sulphide ores, the separation of the zinc from the lead constituents by leaching out the former by means of a solution of alkali metal hydrogen sulphate.

630951—August 15, 1899. L. VANINO. *Wet process of extracting silver from its haloid salts.*

The wet process of extracting silver from its insoluble haloid salts, which consists in mixing said haloid salts with a watering solution of alkaline agents, and adding formic aldehyde in the cold.

635056—October 17, 1899. D. O'KEEFE. *Process of treating ore.*

The process of treating ore, consisting of roasting the same while being agitated, for the purpose of mechanical disintegration, subjecting the ore to hydrogen gas under pressure, afterwards to chlorine gas, and then leaching the same with hot salt water.

635695—October 24, 1899. C. MARTIN. *Process of chemically preparing and treating rebellious ores.*

The process of effecting the separation of gold, silver, tin, lead, and platinum, in pulverized rebellious ore containing arsenic and antimony, which consists in effecting sulphurization and disintegration of the said ore, producing a sulphide solution of the metals in said ore, and thereupon precipitating the dissolved metallic compounds other than arsenic and antimony by mingling the same with an oxide of an alkali earth metal.

635793—October 31, 1899. F. W. MARTINO and F. STUBBS. *Process of treating ores containing precious metals.*

The treatment of ores or tailings containing the precious metals by finely dividing the ore, mixing it with calcium carbide, and moistening the mixture with water.

644770—March 6, 1900. R. W. KENNEDY. *Solvent for leaching ores.*

A solvent for leaching ores, comprising sodium thiosulphate, ammonium carbonate, copper sulphate, and potassium cyanide in water.

647989—April 24, 1900. T. RYAN, JR., and N. HUGHES. *Process of extracting zinc from substances containing same.*

The process of extracting zinc from substances containing the same, consisting in subjecting the raw material to the action of a solution of a caustic alkali, precipitating any lead present by galvanic action, securing the removal of organic matters and iron, manganese, and silicon by the addition of caustic lime and bleaching powder, and finally precipitating the dissolved zinc in the form of zinc oxide or zinc hydroxide by decaustifying the solution by the addition of an acid.

648354—April 24, 1900. C. G. COLLINS. *Process of extracting metals from their ores.*

The process of extracting metals from their ores, consisting in dissolving out or extracting the metal from the powdered ore by means of a solution of ammonium salt in the presence of an alkali base capable of decomposing the ammonium salt, and then precipitating the metal by the addition of a solution of an alkali metal.

652072—June 19, 1900. G. DE BECHI. *Treatment of ore.*

The method of treating complex ores, consisting in subjecting the ore to a chloridizing roasting, condensing the vapors and gases evolved, treating the roasted ore and the acidulated water containing the condensed vapors and gases with calcium chloride to precipitate soluble sulphates and sulphuric acid as insoluble calcium sulphate, then lixiviating the ore with the acidulated water to obtain a solution of zinc and copper salts and fractionally precipitating zinc and copper from the said solution as hydrated oxides by successive additions of lime.

652849—July 3, 1900. S. H. JOHNSON and H. L. SULMAN. *Process of extracting metals from ores or slimes.*

The method of treating pressed slime cakes containing residual water, which consists in displacing the residual water with an equal volume of a solvent solution, mixing the cakes with a further quantity of solvent solution, removing the metal bearing solvent solution by pressure, displacing the remaining portion of such metal bearing solution with water and extracting the metal from said metal bearing solution, whereby all the operations may be performed with an approximately constant volume of the solvent solution.

653414—July 10, 1900. E. FINK. *Process of extracting copper or other metals from tailings or ores of such metals.*

The process of extracting copper and other metals from tailings or ores of such metals, which consists in subjecting the tailings or ore to the action of a solution containing sulphuric acid and to the action of an oxide or oxides of nitrogen in the presence of air or oxygen under pressure, whereby the metal is oxidized and dissolved and the oxide or oxides of nitrogen are converted alternately into a lower and a higher oxide or oxides, and finally separating the solution from the earthy matter of the tailings or ore and separating the metal from the solution.

654804—July 31, 1900. G. RIGG. *Process of obtaining oxide and carbonate of zinc from materials containing zinc.*

The process of producing oxide of zinc and carbonate of zinc from zinciferous material, which consists in leaching the zinciferous material with a solution of ammonia and carbon dioxide wherein the carbon dioxide is in such proportion to the ammonia as to impart to the latter an approximately maximum zinc dissolving capacity.

656497—August 21, 1900. G. DE BECHI. *Process of treating zinc bearing complex ores for recovery of zinc or other metals therefrom.*

The method of treating complex zinc ores for the recovery therefrom of copper, zinc, and lead, consisting in separately roasting the ore and an alkali chloride in the presence of air and steam, conveying the sulphurous and sulphuric vapors thus derived from the ore over and in contact with the said chloride during the roasting to obtain hydrochloric acid fumes, condensing the acid fumes, lixiviating the roasted ore with the acid liquor thus obtained to produce a solution of metallic chlorides, and successively precipitating the metals of the metallic chlorides as hydrates by successive additions of alkali.

656544—August 21, 1900. H. HIRSCHING. *Process of treating gold and silver ores.*

The process of treating copper ores, which consists in adding the comminuted ore gradually under agitation to an ammoniated solution, and then adding a diluting liquid to the mixture to obtain a highly concentrated copper solution.

657955—September 18, 1900. H. PETERSEN. *Process of enriching metallic sulphides.*

The process of enriching metallic sulphides, which are mixed with carbonates of the alkali-earth metals, consisting in dissolving out the carbonates with an aqueous solution of sulphurous acid.

659338—October 9, 1900. C. G. COLLINS. *Process of extracting zinc and copper from their ores.*

The process of treating ores of copper and zinc, which consists in immersing the comminuted ore in a solution containing sodium sulphate and bisulphate (niter cake), removing the depleted ore and extracting the metal therefrom by electrolytic action, adding more comminuted ore to the remaining solution, and repeating the operation.

659339—October 9, 1900. C. G. COLLINS. *Process of extracting copper and zinc from their ores.*

The process of treating ores of copper and zinc containing other metals soluble in any excess of solution which may be employed above that required to dissolve the copper and zinc contained therein, which consists in introducing the comminuted ore into a solution of sodium sulphate containing hydrochloric and sulphuric acid (salt-cake solution) not exceeding 5° Baumé, and subsequently recovering these metals from the solution.

659670—October 16, 1900. C. J. HEAD and R. C. WILD. *Method of treating telluride ores.*

A process for the extraction of tellurium from telluride auriferous ores and the preparation thereby of said ores for the better extraction of the precious metal therefrom, consisting of a lixiviation and digestion of the said ores in a solution containing about 5 per cent of caustic potash or soda for a lengthened period of two to six hours, the withdrawal of the solution after such digestion from the said ores, and the recovery of the tellurium from the solution.

660013—October 16, 1900. C. J. HEAD and R. C. WILD. *Method of treating telluride ores.*

A process for the extraction of tellurium from telluride auriferous ores and the preparation thereby of said ores for the better extraction of the precious metal therefrom, consisting of a lixiviation and digestion of the said ores in a solution containing about 5 per cent of carbonate of sodium or potassium for a lengthened period of two to six hours, the withdrawal of the filtrate, and the recovery of the tellurium from the solution.

663759—December 11, 1900. C. HOEPFNER. *Process of producing solutions of zinc chloride.*

The process, which consists in reacting upon an oxide or insoluble salt of zinc in presence of water with sulphurous acid to form soluble zinc bisulphite, converting the bisulphite into a monosulphite by suitable reagents, mixing therewith its equivalent of sodium or potassium chloride and exposing the mixture to heat and air in the presence of a contact substance, such as oxide of iron, in order to convert the monosulphite into a sulphate, separating the zinc chloride from the solution and mixing therewith a sufficient quantity of an aqueous solution of sodium chloride to dissolve the zinc chloride and leave the alkali-metal sulphate practically undissolved.

678210—July 9, 1901. J. W. WORSEY. *Process of treating complex ores.*

Process for the treatment of complex sulphide ores, comprising, first, the reduction of the combined sulphur below 15 per cent by calcination; secondly, finely powdering the calcined ore; thirdly, adding sodium nitrate; fourthly, boiling the mixed ore and nitrate in dilute sulphuric acid; fifthly, roasting the semisolid mass in a closed furnace; sixthly, dissolving out zinc copper and other soluble salts from the said mass by weak sodium-sulphate solution; seventhly, removing any copper from the solution; eighthly, precipitating the zinc and other metals from the solution; and, ninthly, separating the zinc.

679215—July 23, 1901. H. C. BULL. *Method of extracting gold from sea water.*

The method of extracting gold from sea water, which consists in mixing with a quantity of sea water a proportion of milk of lime to react upon the iodide of gold contained in the sea water to form iodide of calcium and to liberate the gold, then allowing the sludge formed by the reaction to settle, then drawing off the water and then collecting the sludge and treating it to extract the metallic gold therefrom.

683325—September 24, 1901. H. J. PHILLIPS. *Extraction of precious metals from their ores.*

The method of extracting precious metals from refractory sulphide or telluride ores without roasting, which consists in subjecting the ore without roasting and in the form of a powder, under heat and pressure, to the action of alkaline polysulphides in solution of such weakness that same will have a selective action, namely, will dissolve the elements which are combined with the gold, and for which the polysulphides have a greater affinity than for gold, without dissolving the gold itself, which latter is thus dissociated and can then be recovered by any known suitable process for recovering free gold.

684578—October 15, 1901. C. W. MERRILL. *Precipitant for recovering metals from solutions.*

The combination with a metal capable of precipitating other metals from cyanide solutions, if a gritty, inert, nonmetallic material, to increase the surface exposed per unit of weight of the precipitating metals.

689835—December 24, 1901. G. H. WATERBURY. *Process of extracting copper from ores.*

The process of precipitating copper in solution, consisting in placing the solution in a tank or receptacle containing pieces of iron small enough to allow the solution to pass readily therethrough, and introducing hot air under pressure into the solution.

692008—January 28, 1902. O. FRÖLICH, M. HUTH, and A. EDELMANN. *Separating process for ores.*

In the art of separating metals from ores containing iron among a plurality of metals existing therein in a combined form, the process, which consists in heating the ore to a temperature below the decomposition temperature of the sulphate of the metal to be sulphated, but above the decomposing temperature of the sulphate of any other metal existing in the ore, and then passing over it a gas mixture containing sulphur dioxide and oxygen.

693148—February 11, 1902. E. B. PARNELL. *Process of treating ores.*

In the treatment of refractory ores, the process, which consists in subjecting them to the action of chromic acid and then roasting them.

695306—March 11, 1902. M. M. HAFF. *Separation of the constituents of complex sulphide ores.*

The process, which consists in heating mixed sulphides of zinc and lead with sulphate of an alkali metal, treating the resultant mass with a dissolving agent to dissolve the zinc sulphate and alkali-metal sulphate, while leaving the lead sulphate undissolved, and adding barium hydrate to the mixed solution of zinc sulphate and alkali-metal sulphate to precipitate zinc hydrate and barium sulphate.

699326—May 6, 1902. T. A. IRVINE. *Extraction of copper by the wet method.*

A process for the extraction of copper, consisting in the treatment of the ore within a mixed solution of chloride of sodium and sulphuric acid, in which solution there is an excess by weight of the chloride of sodium in respect to the sulphuric acid.

700311—May 20, 1902. F. ELLERHAUSEN. *Treatment of complex and refractory ores.*

The process of treating complex and refractory ores containing lead, silver, and zinc, which consists in smelting the raw ores, churning the fumes and gases with water to condense and mix them with water, settling out the lead, silver, and part of the zinc compounds from the resulting liquor, as a sludge, separating and drying the sludge and fusing the sludge with caustic alkali, thereby precipitating the lead in metallic form.

702047—June 10, 1902. C. G. COLLINS. *Process of rendering metallic sulphides soluble.*

The process of rendering metallic sulphides soluble, consisting in drenching the crushed sulphide ore with aqueous ammonia, draining off the excess of aqueous ammonia, treating the ore thus moistened to an excess of oxygen, leaching the ore, and repeating the operation until the metal is all extracted from the pulp.

702153—June 10, 1902. J. P. VAN DER PLOEG. *Treatment of ores and materials containing antimony.*

The method of extracting antimony from ores, materials, or residues containing it, consisting in finely pulverizing the material, mixing it with a suitable quantity of powdered quicklime, and then mixing with it an adequate quantity of sulphide of an alkali-earth metal and water, so as to form a solution of the lower and most soluble double sulphides as being the best electrolytes, without the use of artificial heat or application of pressure.

702244—June 10, 1902. A. J. POLMETEER. *Precipitant for treatment of copper water.*

The precipitant for copper water, containing in solution a sulphide and an excess of alkali.

702582—June 17, 1902. J. W. NEILL and J. H. BURFEIND. *Process of recovering metals from ores.*

The improvement in treating copper or other ores, consisting in agitating a charge of pulp containing the ore by gas from roasting furnaces charged with material suitable for producing sulphurous-acid gas, separating the resultant solution, precipitating the metal from the solution, thereby releasing gas and employing the sulphurous-acid gas released by the precipitating process to enrich the gas derived from the furnace and used in leaching a charge of ore.

704640—July 15, 1902. C. HOEPFNER. *Process of extracting copper and nickel from sulphide compounds.*

The process, which consists in oxidizing roasting copper and nickel sulphide ores or mattes, leaching the sulphate of copper formed, converting this into cupric chloride and then into cuprous chloride, dissolving the nickel salts in the residue by said cuprous chloride, precipitating cuprous chloride from the solutions formed and returning the resulting solution containing some cuprous chloride into the cycle of operations.

704641—July 15, 1902. C. HOEPFNER. *Process of extracting zinc or other metals from their ores.*

The process, which consists in reacting on a material containing an oxygen compound of metals insoluble in water and whose chlorides are soluble in a solution of alkali metal chloride, with sulphurous acid and an aqueous solution of alkali metal chloride, whereby a solution is formed containing a chloride of a metal.

706302—August 5, 1902. L. B. DARLING. *Means for extracting precious metals from ores.*

In a gold extracting plant provided with a substantially flat treating floor of nonabsorbent material, a series of longitudinally extending channels formed therein, a transverse groove or end launder in direct communication with said channels, fixed screens or strainers covering the top of said channels and launder, side launders or ducts, and valved connections interposed between and uniting the said end and side launders.

707107—August 19, 1902. J. HERMAN. *Process of treating ores.*

The process, which consists in roasting sulphide of copper ore at a low heat to form sulphates of the copper and some of the iron present, and produce a large percentage of ferrous sulphate, leaching the roasted ore, precipitating the metallic copper, and adding salt to the leaching solution before or after the precipitation of the metallic copper, whereby the ferrous salts in the solution are converted to the chloride, and a solution having an excess of salt is produced, and the said solution is adapted to dissolve copper and silver out of carbonate and oxide ores.

707506—August 19, 1902. E. FERRARIS. *Method of treating mixed sulphide ores.*

The process of decomposing mixed sulphide ores by means of concentrated sulphuric acid without the aid of extraneous heat.

709037—September 16, 1902. W. PETHYBRIDGE. *Treatment of telluride gold ores.*

In the decomposition of ores containing telluride of gold, the process of reducing the ore to a finely divided state and then exposing the ore to the action of a solution of ferric chloride alone to attack the tellurium.

715023—December 2, 1902. J. C. CLANCY and L. W. MARSLAND. *Process of treating zinc sulphide ores.*

In extracting metals from zinciferous sulphide ores, roasting pulverized ores with the addition or admixture of lead sulphate obtained from a source external to the ore being treated in quantity proportional to the quantity of zinc the ore contains.

715771—December 16, 1902. F. ELLERHAUSEN and R. W. WESTERN. *Treatment of zinc ores.*

The process for the treatment of zinc ores and other zinciferous matter, consisting in calcining where necessary, wetting with a dilute solution of ammonium sulphate, adding sulphuric acid, washing with ammonium sulphate, and precipitating with aqueous ammonia and heating the precipitate.

715804—December 16, 1902. H. E. HOWARD and G. HADLEY. *Treatment of spent acid from galvanizing works.*

The treatment of spent acid from galvanizing works by adding zinc thereto, separating the solution from the precipitate, treating with bleaching powder to transform the ferrous salts into ferric salts, then adding alkali to precipitate the iron present as ferric hydrate, and subsequently more alkali for the precipitation of the zinc salts.

716847—December 23, 1902. F. W. MARTINO. *Treatment of ores containing precious metals.*

The process of separating gold from ores containing tellurium, selenium, sulphur, arsenic, antimony, tin, phosphorus, or the like, consisting in grinding the mixture, heating it with powdered barium sulpho carbide in a reducing (muffle) furnace, dissolving out the soluble sulphides thus formed, treating the solid residue with a gold solvent, and precipitating the gold therefrom by the employment of barium sulpho carbide.

717299—December 30, 1902. G. C. STONE. *Extraction of zinc and lead from sulphide ores.*

The method of separating zinc and lead from sulphide ores, which consists in smelting the sulphides, oxidizing the volatile constituents at their exit from the smelting furnace, cooling the resulting fumes and products of combustion to a temperature not exceeding 180° F., and passing them into contact with a solvent which will dissolve out one of the metals and not the other.

717565—January 6, 1903. A. VON GERNET. *Process of extracting copper from its ores.*

The process of extracting copper from its ore, which consists in slowly passing the ore in the form of pulp through a current of sulphurous acid, passed in a direction opposite to that of the travel of the pulp.

717864—January 6, 1903. J. T. JONES. *Method of treating ores.*

The process of mixing with ore, to be treated, a leaching fluid, which consists in confining the mass of ore in a vessel with a body of leaching fluid of lesser specific gravity superimposed upon it, carrying portions of the ore upward in said vessel and releasing it above the body of leaching fluid, to precipitate it through said body and simultaneously convey portions of the leaching fluid below the surface of the mass of ore and releasing it, and permitting it to rise through the same.

718099—January 13, 1903. S. C. C. CURRIE. *Method of reducing ores.*

The step in the art of treating pulverized ores containing precious metals, which consists in subjecting the ore, in a closed vessel, to the action of hot air at a temperature which reduces some of the salts in the ore from an insoluble to a soluble condition in water, then washing away the soluble salts with water and then repeating the step with air at a higher temperature.

719132—January 27, 1903. W. PAYNE, J. H. GILLIES, and A. GONDOLF. *Process of treating copper ores.*

The process of treating copper ores, consisting in first roasting to an oxide, next saturating the same with a solution of ferrous sulphate or sulphate and chloride, next roasting again and meanwhile adding a small percentage of iron sulphide or sulphur, according to the percentage of copper present, and finally leaching the hot ore.

719757—February 3, 1903. S. C. C. Currie. *Process of treating ores containing precious metals.*

The method of treating ore, which consists in heating the raw pulverized ore in contact with steam, and plunging the heated ore into an aqueous alkaline solution.

723787—March 24, 1903. S. Trivick. *Process of extracting metals from ores.*

A process for evolving nascent chlorine and effecting the chlorination of metallic substances in order that they may be extracted from a metalliferous mass by rendering them solvent, consisting in adding to the mass a mixture in definite proportions of two substances, one being dry chloride of lime and the other ferric sulphate, the proportions being such as to result in the formation of ferric hypochlorite and ferric chloride which will evolve nascent chlorine.

723949—March 31, 1903. G. D. Van Arsdale. *Process of separating copper from ores.*

The process of extracting copper from ores, or products containing copper, which consists in separating copper from cupric-sulphate solutions, with or without ferrous or other suitable sulphate, and of simultaneously producing free sulphuric acid, by adding to such solutions sulphur dioxide and heating with or without pressure, whereby copper or copper compounds are thrown down in the solid form to be subsequently treated, and free sulphuric acid is formed, and of adding the acid liquors thus obtained, after separation from the copper precipitate, to copper ores, whereby the copper contained in them is dissolved and the original solution regenerated and the process repeated and thus made continuous.

724414—March 31, 1903. G. H. Waterbury. *Copper leaching process.*

The copper leaching process, consisting in placing the suitably pulverized ore in a leaching tank, adding water, acid, common salt, and oxide of manganese in suitable quantities, heating the mass by the introduction of steam to a suitable temperature, and finally subjecting the pulp to agitation during a suitable period.

725257—April 14, 1903. T. B. Joseph. *Gold extraction process.*

The process of extracting precious metals from ore containing the same, when in a suitable condition, which consists in subjecting the said ore to a leaching action of a solution of water, cyanide of potassium, hydrate of calcium, carbon dioxide, and bromine, and subsequently precipitating the precious metals from the solution.

725548—April 14, 1903. H. R. Ellis. *Process of extracting copper from carbonate and oxide ores.*

The process of extracting and recovering copper from its carbonate or oxide ores or from material carrying carbonates or oxides of copper, which consists in subjecting the ore or other material in a crushed or powdered state to the action of a carbonate of soda or its described equivalents until the copper is dissolved and subsequently subjecting the charged solution to electrolytic action.

726802—April 28, 1903. B. T. Nichols. *Ore treating process.*

The process for treating ore preparatory to leaching, consisting first in mixing the suitably pulverized ore with lime; second, applying water to the mixture and introducing steam whereby the pulp is agitated and kept at a suitable temperature until certain impurities which retard leaching are freed; third, washing the pulp by the introduction of water and continued agitation; fourth, draining off the water as far as practicable; and, finally, drying the ore.

729760—June 2, 1903. G. V. Gusman. *Process of reducing and separating silver.*

The process of extracting and separating silver from its ores, which consists in subjecting roasted ores to the action of a preprovided aqueous solution of cupric chloride and cuprous chloride, passing the resulting solution through granulated metal, and removing and collecting the metallic silver from said metal.

729819—June 2, 1903. J. F. Webb. *Apparatus for use in extracting metals from ores.*

A tank for use in extracting metals by chemical process from their ores, having a filter bottom and means for discharging air within the tank and downwardly upon the said bottom, whereby the said bottom is kept free from clogging and air is supplied to agitate the mass within the tank and supply oxygen thereto.

734683—July 28, 1903. J. F. Duke. *Process of obtaining gold from sea water.*

The process of obtaining gold from sea water containing the same, which consists in precipitating the gold by carbonate of calcium.

735098—August 4, 1903. C. Hoepfner. *Process of obtaining lead or other metals from ores or mattes.*

The process, which consists in leaching compounds containing lead and iron with a solution of cupric chloride containing a solvent of the chlorides of said metals, supplying oxygen to produce oxychloride of copper whereby the iron is precipitated, and precipitating the lead as a sulphite by means of a sulphite of zinc.

735512—August 4, 1903. H. Hirsching. *Treatment of ores containing gold, silver, copper, nickel, and zinc.*

The process for extracting gold, silver, copper, nickel, and zinc from substances containing the same, which consists in subjecting said substances to the action of an acid, washing with water the substance thus treated, thereby forming solutions containing compounds of gold and base metals, and then subjecting said solutions to the action of ammonia for the purpose of precipitating the gold and recovering the base metals from the solution separately, and also the ammonia.

739011—September 15, 1903. F. Laist. *Process of treating ores.*

The method of generating hydrogen sulphide and precipitating copper, which consists in subjecting an alkaline-earth sulphide in presence of water to the action of carbon dioxide, thereby generating hydrogen sulphide and precipitating the carbonate of the alkaline-earth metal, conducting said hydrogen sulphide into the presence of copper in solution, thereby precipitating copper sulphide and forming a solvent liquid, treating copper ores with said solvent liquid, and collecting said alkaline-earth carbonate and reconverting it into sulphide.

740014—September 29, 1903. J. Herman. *Process of treating ores.*

A process of extracting copper from ores, which consists in treating ore containing iron to produce ferrous chloride, utilizing the chloride and free acid to dissolve carbonates and oxides of copper, the free acid being adapted to neutralize interfering substances and to attack the surface of the particles of copper oxide or carbonate, and regenerating the free acid by the electrolytic precipitation of copper.

740372—September 29, 1903. C. Rogers. *Process of extracting zinc from sulphide ores, etc.*

The process for the extraction and recovery of zinc from zinc containing sulphide ores or tailings, which consists in subjecting the same to a partial sulphatizing roast, discharging the same while hot into water, leaching the same with said water and with dilute sulphuric acid, subjecting the leached ores or tailings to a second sulphatizing roast, releaching the same with the lixivium from the former leaching, and repeating said operations until sufficient zinc and sulphur are removed.

740701—October 6, 1903. A. M. G. Sebillot. *Treatment of sulphide ores.*

A process for treating ores containing sulphur consisting of sulphating the ore in a closed vessel by the action of sulphuric acid upon the metallic sulphides at a temperature above its boiling point and simultaneously recovering the sulphuric acid used, calcining the sulphated ore at a temperature of 700° Centigrade to dissociate the sulphate of iron to prevent dissolving of a too great quantity of sulphate of iron in the lixiviating liquors, and then lixiviating the calcined ore.

748662—January 5, 1904. A. M. G. SEBILLOT. *Process of treating copper ores.*

The process for extracting pure metals from mineral ores, consisting in treating the ores with sulphuric acid at the evaporating point of the latter, without roasting, to form sulphates, condensing the surplus acids fumes, and lixiviating the sulphates in successively deeper baths under constant agitation, in a current flowing in direction opposite to the progress of the ores.

749700—January 12, 1904. P. NAEF. *Process of lixiviating ores.*

The method of lixiviating ores or other pulverulent materials, which consists in passing the ore downward in thinly divided layers through an ascending stream of leaching solution and at the same time passing a current of air or gas repeatedly through the ore layers in numerously divided jets, whereby the ore particles are agitated in the solution, and the same volume of gas acts successively as an agitating medium.

752320—February 16, 1904. J. B. DE ALZUGARAY. *Extraction of metals from complex ores.*

In the treatment o. complex ores, such, for instance, as contain copper, lead, silver, and zinc in comparatively large quantities, the process of extracting the said metals selectively, which consists in leaching the ore with a solution composed of a mixture of a chloride of an alkali or earth-alkali metal with a chloride of a metal other than those of the alkali or earth-alkali series and an acid before calcination or roasting whereby the copper is obtained in solution, then washing and drying the ore, roasting the partially disintegrated ore at a low temperature, extracting the metals from the roasted ore in form of salts by means of a second and weaker leaching solution having a character consonant with the nature of the salt it is desired to obtain, and recovering the metals in the usual way.

754643—March 15, 1904. K. DANZIGER. *Process of separating iron pyrites from zinc-blende.*

A process for separating iron pyrite from zinc-blende, which consists in exposing the zinc-blende to the action of air moisture and heat, and extracting the ferrous salt which has been formed by the oxidizing action by water.

755871—March 29, 1904. T. A. HELM. *Apparatus for treating ore.*

An apparatus for treating pulverized auriferous ores, comprising a rotatable cylindrical tank, radially depending blades in the tank extending the length thereof, a circular brace-frame disposed between the inner ends of the radial blades, an air pipe leading into the tank, faucets to draw off a liquid from the tank, and means to rotate the tank.

CLASS 75.—METALLURGY.

Subclass 86.—Solution and precipitation—Apparatus.

108158—October 11, 1870. W. S. LAIGHTON. *Improvement in apparatus for precipitating gold and silver from solutions.*

The invention consists in combining two vessels—one to receive the solution to be precipitated and the other the precipitant—and connecting them by an automatic apparatus that shall deliver a certain quantity of the precipitant into the other vessel every time it is filled and provide for the discharging of the same, the quantity of the solution that receives the precipitant, measured out, being governed by a hydrometer or hydrometric float, which is used to operate the apparatus.

213382—March 18, 1879. C. C. BITNER. *Improvement in apparatus for obtaining metallic copper from its solution.*

The invention relates to a novel apparatus for obtaining metallic copper from its solution; and it consists in the employment of a tank or vat having a horizontal perforated diaphragm, upon which is placed a quantity of iron. This tank is filled with a solution of copper, previously prepared from the roasted ore in the usual manner. Through the top of this tank a steam pipe passes and extends below the diaphragm, so that the solution is heated by this injected steam, and, by the motion which its action gives, the deposition of the copper is hastened. By means of peculiarly arranged slides the steam is admitted above the diaphragm through holes in the steam pipe to assist the process, if desired.

234073—November 2, 1880. R. SCHULDER and E. H. RUSSELL. *Ore-leacher.*

The invention consists of a circular frame supporting the filter and moving on a circular track above an inclined circular table; and it consists, further, of three stationary rollers, designed to elevate and depress the filter at certain points as it revolves, of a device for feeding the substance to be leached upon the filter, of a device for applying the leaching solvent, and of a precipitating tank to contain the solution passing through the filter.

248768—October 25, 1881. J. F. N. MACAY. *Filter.*

The invention relates to improved apparatus for use in effecting the operations of dissolving solids in liquids and producing chemical reactions, and of filtering or separating liquids from solids in chemical and metallurgical processes, in which a soluble substance or substances, mixed or combined with an insoluble substance or substances, is or are to be dissolved separately or together, wholly or partially, in a given solvent or solvents, and the solution separated by filtration from the undissolved residue.

In effecting the separation of liquid from solid matters by filtration it is of importance to keep the filtering surface from being clogged by the particles of solid matter, and to present a clear and unobstructed filtering surface for effecting the rapid separation of the liquid from the solid matters. In the apparatus of the invention this important condition is realized in a very effective manner, the construction and operation of the apparatus being as follows:

Within a cylinder of wood or other material not chemically acted on by the materials treated or the reagents employed is inclosed an inner cylinder of hard wood, or of hard earthenware or stoneware or other material not chemically acted on by the materials treated or the reagents employed, this inner cylinder being perforated with holes and lined internally or externally, but preferably internally, with asbestos cloth or other suitable filtering material.

Between the inner and outer cylinder there is an annular space, and the inner cylinder is kept in place by longitudinal and circumferential partitions, the former of which divide the annular space into a number of distinct compartments, each provided with a draw-off cock for running off the liquid when separated by filtration. This cylinder is capable of being rotated, and is provided with doors or manholes in one of the heads by which the matters to be treated may be introduced and the undissolved residue removed; and the cylinder is also provided with a tubular journal or journals for the introduction of steam, water, air, or other liquids or gases, under pressure or otherwise, which may be blown, forced, or drawn into the annular space for the purpose of keeping the filtering surface clear and of acting chemically or mechanically upon the contents of the cylinder. I place within the inner cylinder the ore or other matter to be treated (previously ground or otherwise reduced to a pulverulent state), together with the reagents or solvents by which it is to be treated. By imparting rotary motion to the cylinder (the draw-off cocks and manholes being closed) the solid matters are brought into intimate contact with the solvents or reagents, and by forcing steam, water, air, or other liquids or gases into the space between the inner and outer cylinders, and thence through the filtering medium into the inner cylinder, any solid matters that may adhere to the filtering surface are disengaged therefrom, whereby the said surface is kept clear, the solid matters are kept in suspension in the liquid, and chemical action, which the liquid or gaseous reagents may be capable of exerting on the said matters, takes place under the most favorable circumstances as regards the intimate mixture of the reagents with the matters and the large surfaces exposed to their action. The annular space between the inner and outer cylinders being divided into compartments by longitudinal divisions, the liquid which passes through into it is carried round by the rotation of the cylinder and flows back into the inner cylinder, thus helping to keep the filtering surface clear and unobstructed. When the soluble substances are dissolved or chemically acted upon, and it is desired to separate the liquid from the solid matters, the draw-off cocks are opened, and then, by giving a slow rotary motion to the apparatus, the liquid may be decanted off from the bulk of the solid matter and at the same time filtered from any such matters which it may hold in suspension by passing through the filtering medium. By this rotary decanting action a practically clear filtering surface, unobstructed by solid matter, is constantly presented for the liquid to pass through.

251718—January 3, 1882. A. E. Jones. *Apparatus for separating gold from quartz and rock tailings.*

The invention consists in the arrangement and application of a suitable fibrous material in combination with machinery, so that the fibrous material will unite or collect to itself the gold and carry and deposit the same to a place designated, where it may be collected and treated as desired in separating the precious metal from its sand and ore. Any fibrous matter that will form a pulp when mixed with water is used to coat a wire-cloth screen as in paper making, and then entangle the fine gold in suspension in the water.

301460—July 1, 1884. J. L. Russell. *Slime filter.*

The invention consists of a trough containing at intervals within it a series of double filtering boxes covered with wire gauze and filled with charcoal, sponge, or any known filtering substance, and the claims cover the trough poised over filter sections provided with adjustable partitions, as well as the combination of a sand box, a sluice provided with adjustable partitions, filters composed of frames and wire gauzes, and gutters.

325835—September 8, 1885. H. C. and J. A. Henderson. *Apparatus for concentrating ores.*

The apparatus for concentrating ores, consisting of an outer tank, an inner filtering tank, provided with fabric ends, and a perforated feed box having its lower end below the top edge of the tank, a space being left between the sides, ends, and bottom of the tanks whereby, when the water is received by the perforated feed box, it will pass into the inner tank and slowly filter through the fabric ends thereof and flow over the top edge of the outer tank, the fabric ends preventing the formation of a current and causing the particles of ore to be precipitated.

366103—July 5, 1887. O. Hofmann. *Process of extracting silver from its ores by lixiviation.*

The invention relates to a certain improvement in the lixiviation process by which the ore, after having been subjected to a chloridizing roasting, is introduced in a series of troughs, first, together with water to dissolve the base-metal chlorides, and, second, together with the solution used in the ordinary lixiviation process to dissolve the silver. The ore and water are introduced either by means of a mixing box or an agitator, and are allowed to flow in these troughs for some distance, and finally conveyed by them into settling tanks. The water while running in the troughs dissolves the base-metal chlorides. In the settling tanks the ore separates quickly from the liquid. The latter is drawn off and conveyed to other tanks for the usual treatment. The ore sediment containing the silver is now sluiced or charged again in a similar series of troughs with a solution which has the property of dissolving chloride of silver, like hyposulphite of lime or soda, concentrated salt solution, Russel's "extra solution" (a compound of hyposulphite of lime or soda and bluestone), etc. By passing through this second series of troughs the silver chloride dissolves. Ore and solution run into tanks which are provided with filter bottoms and allowed to separate. The tailings settle to the bottom, while the clear solution, now containing the silver, is drawn off and conveyed into the precipitation tanks for the usual treatment.

370871—October 4, 1887. F. F. Hunt. *Apparatus for agitating solutions in the leaching of metals from their ores.*

The invention relates to an improvement in apparatus for agitating the acid solutions formed in the leaching of copper and other ores; and the object of the same is to provide a form of rotary agitator in which the heavier portions of the charge can not accumulate at the center of the apparatus and escape the action of the agitating arms, which will also produce a more perfect agitation of the solutions than has heretofore been possible, and which will be more durable and economical to construct than the forms in present use.

Heretofore the agitators used in leaching works have usually been made with flat bottoms and have been provided with stirring or agitating arms of conical shape at the base, arranged to rotate a slight distance above the bottom. In the invention this arrangement is reversed, and the agitating tank is constructed with a cone of small altitude placed apex upward in the center of the bottom and covering a considerable portion thereof, and is provided with agitators, the arms of which are provided with concave shoes and are arranged to rotate in close proximity to the cone in the bottom of the tank.

412610—October 8, 1889. J. B. Hannay. *Apparatus for applying chlorine to the extraction of gold from ores.*

This invention relates to means of extracting from ores precious metals, especially gold, in the form of chloride solution. For this purpose an apparatus is employed which consists of a chlorinating vessel, a set of circulating pumps, a filter press, and a chlorine pump, or sets of these, with suitable communicating pipes, cocks, and valves for operating in the following manner: Having reduced the ore to a fine powder, it is mixed with water or with chlorinated water to a condition of thin sludge, which can be pumped. Then charge the chlorinating vessel with this sludge and apply the pumps to cause its circulation therein, drawing from the upper part and discharging into the lower part, while chlorine gas is pumped into the vessel, preferably to a pressure considerably above that of the atmosphere. After circulation has gone on for some time, until the metal in the ore is mostly dissolved by the chlorine, the sludge is pumped by the circulating pumps into the filter press, additional pressure being given, if required, by using the chlorine pump to force air into the upper part of the chlorinating vessel. The liquid issuing from the filter press containing in solution the metallic chloride is treated in any of the known ways for separating the metal and recovering the chlorine. In some cases the solution discharged from the filter press may be used in a subsequent operation to form the sludge by its admixture with a fresh quantity of pulverized ore, and this may be done repeatedly, so as to obtain finally a filtered liquor rich in chloride.

As it is advantageous to charge the chlorinating vessel with an excess of chlorine above that which enters into combination with the metals, the inventor prefers to collect such excess before discharging the sludge by blowing in a little steam to warm the sludge and allowing the free chlorine thus liberated to pass either into a gasometer or into another chlorinating vessel; or an exhaust pump may be employed to draw off the free chlorine.

When metals such as silver are present, having insoluble chlorides, the blocks which are taken from the filter press, and which contain these chlorides, may be reduced to sludge, as before mentioned, and may be subjected to the same treatment with a suitable solvent instead of the chlorine.

418138—December 24, 1889. J. S. MacArthur. *Metallurgical filter.*

A metallurgical filtering apparatus for separating a precious metal from a solution containing said metal, consisting of a series of vessels, each of which has an inlet tube near its bottom, an outlet tube near its top, and a perforated false bottom above the inlet tube, zinc sponges disposed in the several vessels, pipes connecting the inlet and outlet tubes of the several vessels, and a reservoir for supplying the solution to the first vessel of the series.

425025—April 8, 1890. D. DENNES and T. K. ROSE. *Apparatus for leaching ores.*

In a leaching apparatus, a movable table, having a flange or wall projecting from its upper surface to form a receptacle for filtering material, the said receptacle being of less diameter than the upper surface of the table, whereby a packing receiving ledge projects beyond the base of the said wall or flange, combined with the leaching cylinder, the lower end of which is constructed to receive said wall or flange, while the ledge abuts against said lower end of the cylinder.

442262—December 9, 1890. S. TRIVICK. *Apparatus for treating ores to obtain precious metals therefrom.*

This invention relates to improvements in apparatus forming a plant for treating roasted ground ores to obtain precious metals therefrom, adapted for use in treating roasted ground ores of precious metals that have been roasted by any known or suitable method.

The apparatus consists, essentially, of a vessel (preferably employing a pair at least of such vessels, so as to change from one to the other of the pair in working) having a porous bottom on which the ground roasted ores rest; means of supply of leaching liquid controlled by valve; means of drawing off leached liquid, conveyance thereof to, and means of stirring said liquid in a mixing chamber—a filter vessel having a porous floor—and means of pumping the filtered liquid to a reservoir; means of evaporating the leaching liquor to recover the contained salts; also recovering the copper salts for reuse, and means of heating the leaching liquid, and also means of desiccating the product.

The invention also consists in a furnace for roasting ores of precious metals, comprising, among other features, a chamber, coils of piping, a tank, reservoir, a force pump, a system of heating pipes, leaching reservoir, tanks with porous floors, and a mixing vessel with rotating stirrers therein.

449813—April 7, 1891. J. CRAGG. *Apparatus for extracting gold or silver from ores.*

In an apparatus for extracting gold or other metals from their ores in solution, a tower and a mixer, which consists of a trough having pipes to conduct the reagents in liquid solution, which enter the same from different sides and terminate out of alignment about centrally of the trough, combined with a hopper placed over the ends of the said pipes and an overflow plate leading to the said tower.

456323—July 21, 1891. P. L. GIBBS. *Ore leaching machine.*

This invention has reference to ore leaching machines in which a rotating annular series of ore receptacles pass successively under an ore vat containing the crushed ore in a solution to receive their respective contents or to be otherwise filled, and to discharge the filtrate during their transit into a suitably placed discharging conduit or launder and at a predetermined point in their orbital movement and automatically discharge the residuum.

The objects of this improvement are, first, to provide a suitably suspended vat to receive the ore in a solution, or dry or roasted ore, and adapted by suitable openings in the bottom thereof to optionally discharge said contents; second, to provide a series of leaching vats to pass successively under said primary vat and respectively receive from the latter a proper quantity of its contents; third, to provide suitable mechanism for supporting and progressing said secondary vats; fourth, to provide a conduit or launder to receive and carry off the filtrate from said leaching or secondary vats; and, fifth, to afford facilities to automatically discharge the residuum from said leaching vats preparatory to their refilling.

463120—November 10, 1891. D. DENNES. *Leaching vat for separating precious metals from their ores.*

An ore leaching apparatus consisting of a closed vat or separating vessel having a removable bottom carrying a filter bed in its upper portion and an auxiliary chamber beneath, provided with a removable bottom and a filter bed, and a suitable pipe connection between the separating vessel and said auxiliary chamber in its bottom.

464672—December 8, 1891. W. D. BOHM. *Apparatus for separating gold and silver from ore.*

The inventor places the powdered or divided ore, or material to be treated for the obtainment of the gold or silver, or both, in a vessel or vat, or vessels or vats, and through it passes the leaching solution, preferably previously heated. By means of a force pump, the leaching solution is forced up through the ore and through a filter at the top. The solution and the precious metal which it now contains pass into a vessel in which it is agitated with a precipitating agent. From this last-named vessel the solution is forced up by a force pump through a vessel having a filtering arrangement, such as a porous diaphragm, at the top, so that the solid matter is retained thereby, the liquid passing off to be heated again and to be restrengthened by the addition of the necessary further quantity of leaching chemicals and passed back to the leaching vat or vats for reuse. The pressure under which the liquids are forced up through the leaching vat and precipitant vessel should be at least eighteen pounds per square inch. At intervals the solid matter retained by the last-named filtering vessel is passed into a filter press or equivalent apparatus, whereby it is deprived of the greater part of its moisture. The ore which has been leached is then drained of all solution and washed free from the last traces thereof with water, preferably hot, and then can be washed out of the vat or vats with acidulated water, and passed over zinc or alloy of zinc with other suitable metal, so that hydrogen is evolved, which reduces any precious metal still remaining in the ore to the metallic state, or such state that it is taken up when the ore is afterwards passed over mercury—for instance, over amalgamated copper.

495385—April 11, 1893. F. WEBB. *Method of and apparatus for extracting precious metals from their ores.*

The inventor claims, in means for extracting precious metals from their ores, the combination of an outer vessel resting in suitable trunnions for containing the reagent or chemical solution, and having inlet and outlet pipes communicating, respectively, with the top and bottom thereof through said trunnions, a perforated vessel in said outer chamber, and adapted to receive the crushed ore, and provided with a manhole opening extending to the outside of the latter, and means for reciprocating the inner vessel and for rotating the outer vessel on its trunnions; whereby the contents of the inner vessel may be discharged. Also, the method of separating precious metals from their ore, consisting in placing the disintegrated or crushed ore in a closed perforated vessel and causing the latter to reciprocate in the reagent or chemical solution, whereby the latter is enabled to more effectually act upon the ore.

497856—May 23, 1893. C. G. BROWN. *Ore tank.*

In a tank for leaching or saturating ore, the combination with a false bottom and a piece of textile material laid upon the upper side of said false bottom; of a series of vertically disposed perforated tubes designed and adapted to hold the pieces of ore apart and promote the circulation of the leaching or saturating solution.

525970—September 11, 1894. J. STORER and B. T. LACY. *Method of and apparatus for dissolving, leaching, and filtering.*

The inventor claims the improved method of dissolving, leaching, and filtering, consisting, essentially, in connecting a plurality of closed tanks in series, then introducing an expansible medium upon a body of noncompressible fluid contained in a terminal tank to force the said fluid under pressure into the successive tanks and through the material under treatment until it reaches the final tank, then connecting this last-named tank with the initial tank, and finally introducing pressure in the said final tank to force the fluid therefrom so that it may be returned to said initial tank. And in an apparatus for dissolving, leaching, and filtering, the combination of the tank adapted to contain the material to be treated, a tank adapted to contain a noncompressible fluid and connected with a source of steam, gas, or vapor supply, a valve-controlled pipe from said fluid tank to said material-containing tank, a final tank beyond the material-containing tank, a valve-controlled pipe connecting said material-containing tank with said final tank, whereby the fluid is forced into said final tank, a valve-controlled pipe connecting said final tank with the initial fluid tank, and means for admitting an expansive medium into said final tank to force the fluid therefrom back into the initial tank.

530397—December 4, 1894. N. H. CONE. *Filter barrel.*

In an apparatus of the class described, the combination with a revoluble cylinder having a hollow trunnion, and a head provided with radiating channels having independent valves of a filter arranged in said cylinder and valves for opening or closing said channels independently of each other.

536981—April 2, 1895. T. L. WISWALL and J. B. FRANK. *Receptacle for recovering precious metals from solutions.*

This invention relates to apparatus wherein the recovery of the precious metals from cyanide and other solutions is effected by passing the solutions through a filtering material, by which the precious metals are precipitated. And the inventor claims, in apparatus for the extraction of precious metals from solutions, the precipitating box, having an undulating, sinuous passage from end to end, comprising a series of alternate angular depressions and elevations, provided with a series of retaining pins, attached to the interior of said precipitating box, and extending into the precipitating, filtering material within said passage.

549177—November 5, 1895. T. L. WISWALL and J. B. FRANK. *Apparatus for recovery of precious metals from their solutions.*

The inventors claim, in apparatus for the recovery of precious metals from their solutions a precipitating box adapted to contain a finely subdivided, metallic, precipitating reagent, divided into a series of compartments by removable perforated partitions, said partitions being provided with adjustable gates, controlling the flow of said solution through the perforations in said partitions for the purposes indicated.

549622—November 12, 1895. P. ARGALL. *Apparatus for extraction of precious metals.*

The specifications set forth that in the treatment of ores by the cyanide process to extract their gold and silver contents, it is the usual practice to place the ores in open leaching tanks and allow the cyanide solution to percolate through the mass and so dissolve and remove the precious metals in solution. This method is on the whole fairly efficient, but it occupies considerable time (forty to eighty hours) and causes a large consumption of cyanide through decomposition, owing to its long contact with the ore and atmosphere. With many classes of ore, however, it is found that agitation of the ore and solution is necessary in order to obtain the best results or largest extraction of precious metals. Particularly is this the case with silver-bearing ores or ores carrying considerable value in silver.

The agitators heretofore in use shorten the time necessary to dissolve the precious metals; but they invariably cause a large consumption of cyanide, due chiefly to the continuous agitation of the solution in open tanks or in partly filled barrels in the presence of an excess of air, while the ore when discharged from the agitators is in such a condition that very often it can not be leached, or at best but part of the cyanide solution containing the dissolved gold can be separated from the ores. Then again, the agitators now in use are of such small capacity as to add largely to the cost of treating the ores.

This invention relates to a new machine for treating ores by continuous agitation and continuous percolation under pressure or by means of vacuum and either with or without external or additional heat. And the inventor claims a percolator for treating ores by the cyanide process comprising an outer shell capable of being closed, air-tight, hollow trunnions upon which said vessel rotates, concentric tubes extending axially through the vessel, the outer tube being covered by a filtering medium, a passage connecting the annular space between the tubes with one of the hollow trunnions, and a pipe communicating with the chamber surrounding the outer tube. The invention includes other features of a minor or subsidiary character.

552807—January 7, 1896. H. G. WILLIAMS. *Method of and apparatus for extracting metals from their ores.*

In an apparatus for the extraction of precious metals from their ores by the wet process, the combination of one or more castings, with screw conveyers and mixers, means for feeding the solid and liquid matters thereto, and a dam placed at the discharge end of the casing for each conveyer, having its surface inclined upon the side next to the conveyer flights or blades, for the purpose of maintaining the admixture of the liquids and solids by preventing the liquid from traveling faster than the solid and still giving passage by reason of its incline to the travel of the solids over the same; and, in the extraction of precious metals from their ores by the wet process, the method of continuously and uninterruptedly precipitating and separating the metals, which consists in simultaneously introducing the precipitating agent and an independent agitating blast of steam into the solution of metal in direction as described to secure admixture and agitation by a whirling motion and the agglomeration of the precipitated particles of metal, and continuously separating the precipitate by settlement and filtration.

567144—September 8, 1896. S. B. LADD. *Apparatus for leaching ores.*

The object of the present invention is to provide an economical and practical apparatus for the lixiviation of ores, and particularly applicable to cases where a large mass of material has to undergo treatment—as, for example, in the lixiviation of low-grade gold ores by the cyanide process—and where the expense of handling material becomes an important factor with respect to the commercial working of the process. The invention applies, generically, to the lixiviation of comminuted or pulverized material of any character, but it is especially designed for the lixiviation of ores by the cyanide process, for in the treatment of ore pulp or slimes by the cyanide and other like processes a large amount of material, often of a low grade, has to be subjected to the action of an aqueous solution of a cyanide or other solvent, or to the successive action of a series of solutions. The common course of procedure in working the cyanide process on a large scale is to run the ore pulp into large vats and then to cause the proper solutions for leaching out the precious metals to percolate therethrough, for example, first an alkaline solution, when the ore is acid, then a strong solution, then a weaker solution, and finally water to wash the pulp. The vat is then emptied and refilled with fresh ore pulp; also, the solvent process is sometimes worked by agitating the pulp and leaching solution in pans or vessels. Both systems require considerable labor and are intermittent.

Another object of the present invention is to provide means to make the extraction process continuous, so that the ore pulp shall progressively and continuously be associated with the solutions or the washings which may be necessary for thoroughly exhausting the values from the ore. This is accomplished by constructing a leaching tank, in the form of a long trough, which may be divided by one or more fixed or removable bridges into so many trough sections as are required for the several solutions or washings when one leaching is not sufficient; or by providing a series of tanks or troughs operatively arranged with respect to each other, employing in connection therewith a conveyer for the ore pulp adapted to continuously feed the pulp with a steady movement through the several solutions in an uninterrupted flow through the apparatus to the point of discharge without any intermediate stoppage or handling of the same whereby the lixiviation of the ore is effected.

For the purpose of rendering the operation continuous, provision is made for a constant drawing off of the charged solution or solutions from the leaching troughs and an inflow of fresh solution thereto. In the case of the first cyanide solution the inflow is preferably at the ore-entrance end of the trough or trough section and the current is with the ore, thus catching the fine float gold carried by the fresh pulp; but in the subsequent troughs or trough sections, and also in the first, if preferred, the inflow of the solution (or washing water) is preferably made at the ore-exit end and the outflow of the solution is at the opposite end where fresh ore or pulp is entering the trough or trough section. Thus, in this latter case, the flow of the solution is opposite to that of the ore. The fresh cyanide solution first acts upon pulp which is largely leached out, and as the solution becomes more and more charged with the gold or precious metals it meets pulp that is progressively richer in the metals, and the conditions are therefore favorable for effecting a complete extraction of the precious metals by the solvent. As a preferred form of conveyer, slowly-moving blades transverse to the trough or tank are used. These blades extend across the tank with just enough room at the sides for clearance, and they reach from above the surface of the solution down to and into the ore pulp on the bottom of the tank with openings or notches in or along the lower part of the blades for the underflow of the solution. These blades divide the trough or tank into a number of communicating divisions and form what may be called "traveling partitions," moving slowly through the trough from end to end thereof. The lower edges of these blades are preferably fashioned with rake teeth, and they open up and rake along the layer of ore pulp on the bottom of the tank and effect a slow and progressive movement of the mass with a constant plowing therethrough and exposure of fresh portions thereof to the action of the solution, while the solution in the tank as the series of blades move forward has to flow back through the notches or openings in the bottom of the traveling blades from each of these divisions formed by the blades, respectively, into the adjacent rear division, and thus there is secured a constant and steady underflow of the solution in close proximity to the agitated pulp. This flow of the solution is in addition to and distinct from the flow due to the constant addition of fresh solvent at one end of the trough and the drawing off of the charged solution at the other end thereof; but it will be seen that the underflow thus effected prevents a mere surface flow of the solution from one end of the trough to the other. On the contrary, as the flow from the respective divisions of the trough is from the bottom and under each traveling partition or blade, the overflow or discharge from the trough at the end is necessarily of the charged portion of the solution. It will be seen that this method of leaching ores places the ore and the solvent under perfect control, which is a very great advantage with respect to the economical leaching of ores. There is an agitation and constant shifting of the pulp in the solution, which very much accelerates the action of the solvent and shortens the time required therefor, and the speed of the conveyer can be regulated so that the pulp will not remain in the tank or tanks any longer than is necessary, and yet long enough for the extraction of all value therefrom. On the other hand, the flow of the solvent through a tank can be gauged so that it will issue from the tank fully charged or charged to the degree most profitable under all the conditions of the case.

576118—February 2, 1897. W. F. Heathman. *Means for extracting gold and silver from sea water.*

In order to extract said metals, the sea water or salt lake water is passed through a filter made of carbon, and the gold and silver held in solution in the sea water or salt lake water are freed from the chemical combinations in which they occur in the water. The chlorides and bromides of gold and silver in solution when passing through the carbon filter are decomposed by the reducing power of the carbon, the liberation of chlorine, and the destruction of the bromine combination, with the result that metallic gold and silver are precipitated in the carbon filter and deposited in the pores and upon the surface of the carbon. And the inventor claims a tank mounted on suitable supports and provided in its side with an inwardly opening valve or gate, said tank having a perforated bottom, and a filtering medium arranged on the bottom and comprising alternating layers of coarse and fine carbon, a layer of wire cloth, and a perforated top covering.

584627—June 15, 1897. J. J. Deeble. *Apparatus for extracting gold from auriferous material.*

This invention has been devised in order to provide a machine for use in the extraction of gold from auriferous material by the aid of chemical solvents, in order to insure the particles of auriferous material being brought into intimate contact with the cyanide or other solvent solution. It includes a vat or pan to receive the auriferous material to be treated, having at or about its center a vertical shaft or spindle with one or more agitators or stirrers attached to its lower end. Motion is imparted to this shaft or spindle by bevel gearing or other convenient mechanical contrivances, and means are provided for reversing the rotation and controlling the speed of the agitators, as well as for raising or lowering the agitator shaft or spindle. These means may consist of a screw-threaded lifting rod with correspondingly threaded bevel wheel in gear with a bevel pinion fitted with a crank handle, whereby it may be rotated in the required direction; or, if preferred, a rack and pinion may be used for the purpose. The inner side of the wall of this vat or pan is provided with a series of projections which produce eddies or swirls in the material under treatment as it is carried round the vat or pan. In order to drain or draw off the gold-bearing solvent from said vat, it is provided with a vertically sliding valve. A waste discharge valve may also be provided in the lower part of the vat or pan for the purpose of enabling the waste material to be sluiced therefrom after the gold has been dissolved and the gold-bearing solution has been drawn off through the valve above referred to.

587408—August 3, 1897. H. L. Sulman. *Method of recovering precious metals from their solutions.*

This invention has for its object the recovery of precious metals from solutions of the same by means of a new and improved apparatus, the apparatus being constructed to effect the deposition or "precipitation" of the precious metal or metals in solution upon a "precipitating" substance or "precipitant" which is in a solid but more or less finely divided state.

The apparatus is designed to recover these metals from solutions of their haloids by means of the employment therein of dense but more or less finely divided carbon, subsulphide of copper, or other suitable precipitant; again, also, for the recovery of the same metals from their cyanide solutions by means of the finely divided zinc product commercially known as "zinc fume," and generally for analogous requirements.

It is necessary that whatever the nature of the precipitant used and the degree of fineness to which it is found desirable to reduce it primarily, it shall be of greater specific gravity than the liquid or solution desired to be precipitated by it, so that the precipitant shall tend to settle from the liquor by gravitation. Further, it is necessary to this invention that the solution or liquor to be precipitated shall percolate upward through the mass of solid finely divided precipitant.

In an apparatus with parallel vertical sides the upward flow of liquor would tend to carry off finely divided particles of precipitant unless special means were taken to prevent this. Filters tend to become clogged and are generally useless for this purpose, so that the inventor retains the particles of the solid precipitant, upon whose surfaces the precious metals are in course of deposition, within the apparatus by inducing subsidence of them. This is effected by continually reducing the upward rate of liquor flow, which is secured by constantly increasing the area of the liquor column as it rises higher in the apparatus.

The apparatus takes the form of a funnel. The liquor enters (under a sufficient pressure or "head") through the bottom orifice. It then meets with and thoroughly mixes with the mass of finely divided precipitant in a condition of suspension in the liquor. The solid, finely divided particles do not sink against the comparatively rapid inflow, or are prevented from doing so to any extent, by means of an automatic valve of ordinary type. By this intimate admixture of liquor with precipitant the deposition of the precious metals in solution in the former is effected upon the minute surfaces of the latter. It now only remains to remove the depleted liquor from the particles of the solid precipitant containing the gold, silver, etc. As the liquor continues its upward flow by virtue of the continually diverging sides of the apparatus the area of the liquor column becomes greater and greater. The rate of the vertical upflow is thereby correspondingly reduced. This continues until a point is reached at which the upflow is vertically so slow that the finest particles are able to settle or subside against it. At any point, therefore, above this limit or "zone" the absolutely clear liquid may be drawn off from the apparatus free from suspended particles and depleted of its precious-metal contents.

If the precipitation of the precious metals be deemed to be incomplete in one apparatus, owing to the richness of the original liquor or to other causes, the outflow may be caused to pass into a second similarly arranged apparatus or through two or more such apparatus placed in series; but in general one apparatus can be made to secure practically perfect removal of the precious metals dissolved in a given liquor by the use of a suitable precipitant. If a series of two or more of such apparatus be employed, the first of the series may be used to enrich quantities of precipitant which have only been partially used up to their fullest capacity of precipitating the precious metals, while the succeeding members of the series are supplied with the necessary amounts of less rich or quite fresh precipitant in order to remove any remaining traces of gold, silver, etc., which may escape unprecipitated in the outflow from the first apparatus. The poorer precipitates in these last apparatus are in course of time removed through the bottom of the apparatus and transferred to the first one of the series, there to be enriched to their full capacity, while their place is taken by fresh quantities of poorer or quite unused precipitating agent, and so on.

When the precipitate is deemed to be sufficiently rich, it is removed from the apparatus by a "three-way cock" at the bottom thereof, or by other suitable arrangement, and the precious metal it contains finally recovered by any suitable method, such as in the case of the employment of a carbon precipitant by burning, or in the case of the use of a zinc precipitant by smelting.

The apparatus is also supplied with a small central funnel for the introduction of fresh quantities of precipitant from time to time to the point of maximum precipitating action in the apparatus, i. e., near the inflow. By providing this funnel with a bell-shaped or inverted-funnel termination a sort of "chamber" is produced in the lower part of the apparatus having an annular space for the passage of liquors between the rim of the smaller funnel and the sides of the large one. This chamber is of considerable aid in promoting the action of the precipitant by keeping the bulk of it constantly near the liquor inflow and securing perfect admixture by means of the vortex currents, etc., it induces. It is further desirable to break up the rapid rush of inflowing liquors at their point of entry into the apparatus, and to secure their subdivision and intimate admixture with the precipitant as early as possible. This is effected by capping the end of the inlet pipe with a small perforated cone or "distributer." The perforations may be from one-fourth to one-tenth the diameter of the inlet pipe, but their total area must be larger than that of the sectional area of the pipe. The holes may be bored in a direction perpendicular to the cap cone or they may be made "tangential," i. e., bored at a tangent to the internal circumference of the cone, thus securing a rotary initial flow of the inflowing liquors instead of a series of straight streams. In the majority of cases, however, perpendicular bore holes answer equally well.

The clear precipitated liquor may be drawn off at any point above the limit of subsidence either by a pipe, or, preferably, by allowing it to flow equally over the rim circumference of the apparatus. The latter method secures the quieter and more uniform outflow and does not disturb the top layers of liquor undergoing final subsidence by establishing a quick current in one particular direction.

If desired, the rim may be encircled with a filter screen of lawn, calico, or other filtering or straining medium, so as to retain within the apparatus any particles of precipitant which may be floated or "buoyed up" by bubbles of air or other gas.

The clear liquors passing over the rim and through the precautionary filter or strainer fall into and are collected by a circular trough or "launder," attached to the apparatus below the rim, whence they are conveyed away by a pipe. As before stated, this may lead into a storage vat or into another similar apparatus, or, if deposition of the floating particles is not absolutely complete, into any suitable type of apparatus—such, for example, as the slat-partitioned tank used for freeing softened water from traces of deposit—where subsidence is finally rendered absolute. In most cases where the traces of precipitant have escaped, I have secured perfect final subsidence by allowing the liquors to flow through a shallow plain tank of from four to six times the area of the top of the precipitating apparatus before passing them direct to the storage liquor vats.

Such an apparatus as is described is termed a "precipitating cone." It may be constructed of any suitable material, such as wood, stoneware, galvanized iron, etc., according to the nature of the liquor or precipitant it is designed to treat. Its action, until the charge of precipitant it contains is exhausted and requires renewal, is perfectly automatic and continuous. Its capacity, its height, the angle of its sides, the ratio diameter of inflow pipe to top area of cone will naturally vary with the volume of liquor to be dealt with, the rate and head of liquor inflow, the relation of the specific gravity of the liquor to that of the finely divided precipitant, the actual coarseness or fineness of the particles of the latter, and so on. These data may be calculated or decided by preliminary experiment in any particular case. As an example, however, of the application of this invention to the recovery of gold bullion from cyanide solutions, the following dimensions of the apparatus are cited: For a flow of from 600 to 800 gallons per hour a depth of 5 feet, with a top diameter of 5 feet, is amply sufficient. The diameter of the inlet pipe is from 1¼ to 1¾ inches, according to the head of the inlet liquor, while the perforations of the cap cone or distributer are three-sixteenths of 1 inch in diameter. The charge of zinc fume in such an apparatus varies from 5 to 30 pounds, according to requirements.

587874—August 10, 1897. E. D. Sloan. *Barrel filter.*

The object of this improvement is to provide a suitable filter barrel, with a durable and highly effective filter, at comparatively low cost. With a view to securing the desired ends the usual trunnioned iron barrel is lined with lead. The framing of the filter bed is composed wholly of suitable wood capable of fairly resisting the action of chlorine and acids, and which may be filled with suitable matter to enable it to better resist the destructive action of the corrosive solutions. The filtering medium is composed of material which resists the solutions, is well protected against undue abrasion due to the action of the solid matter during the rotation of the barrel, and it has its filtering area supported to enable it to safely bear the overlying contents of the barrel by an underlying floor of such metal as will practically resist the action of chlorine and sulphuric acid—as, for instance, a lead floor—and the latter is freely perforated to admit of the prompt discharge of the filtered liquid. The filtering surfaces are flat, and hence the body of any woven filtering medium is maintained in a condition more favorable to the passage of the liquid than would be the case if it occupied a curved line and said surfaces were concave in conformity with the interior contour of the barrel. The framing of the filter bed involves inexpensive straight work as distinguished from the curved or segmental work in framing, which is made to conform to the interior of the barrel as heretofore, and the filter framing is constructed in parts which are so interlocked as to secure rigidity, but which may be readily applied to or removed from the barrel by way of the usual manhole and without deranging the lead lining or the means by which the lining is clamped to the barrel.

597372—January 11, 1898. P. J. Donohue and J. F. Corker. *Precipitating safe.*

The combination with a closed vessel or standpipe provided with a normally closed outlet at its bottom for the precipitate and having a body or column of zinc filings or like material in its upper part, adapted as corroded to fall into the lower part, of means for supplying, under pressure, the solution containing the precious metal to the lower end of the said body or column of filings or like material, to cause the corrosion or oxidation thereof, whereby such corroded or oxidized portions will gradually precipitate to the bottom of the vessel or standpipe and the fresher portions of the filings or like material be exposed to the ascending solution.

606810—July 5, 1898. J. W. Pack. *Recovery of gold from waste solutions of chlorination works.*

A means for recovering gold from waste solutions of chlorination works, consisting of a tank having an inlet passage at the lower portion and an outlet passage at the upper portion and having metallic aluminum contained therein, and intermediate between the inlet and outlet passages of the tank, and a filter fixed within the tank between the metal and the outlet passage and having its lower side coated with a substance which will arrest the fine precipitated gold and prevent it from passing off with the liquid.

608554—August 2, 1898. R. Moodie. *Washing or leaching apparatus.*

In an apparatus for washing or leaching, a series of cells, one of which is a dry cell and the others of which contain washing or leaching liquid, means for introducing the material to be washed into the dry cell, an oscillating shaft extending longitudinally of the series of cells, means operated by said shaft to transfer the material from the dry cell to the washing cell next in series, arms attached to the oscillating shaft and extending one into each washing cell, and scoops on said arms.

608945—August 9, 1898. H. B. Williams. *Lixiviation apparatus.*

In a lixiviation apparatus, the combination of a vertical series of annular tanks arranged one above another and each provided with an exit through which ore or other substances may be discharged into the tank beneath, each tank bottom being provided with an ascending incline leading to one side of the tank exit and having a descending incline on the other side, means for feeding ore into the topmost tank, pipes for conveying leaching solution into the several tanks separately, the feed of the ore to be continuous and the feed of the solution to be continuous or intermittent, filters located in the several annular tanks, and automatic scraping and stirring mechanism to cause the ore and solution to be moved around each annular tank and over the filter therein.

610596—September 13, 1898. R. Aymer and D. J. Nevill. *Filter frame.*

In a filter barrel, the combination of a rubber grating having a corrugated surface in contact with the curved inner lining and periphery of said filter barrel adapted to allow the filtering solutions to run along and down the lining of said barrel, a perforated bedplate of glass or porcelain curved concentric with the inner periphery of said barrel and resting on said rubber grating, a filtering medium on said glass bedplate, a curved glass grating resting on said filtering medium, two oppositely disposed cleats secured lengthwise of said barrel to its inner periphery adjacent to the ends of said curved glass bedplate and grating, and wedge keys between said ends and said cleats adapted to key said members against the barrel.

611515—September 27, 1898. J. P. Schuch, Jr. *Means for extracting precious metals.*

In a metallurgical apparatus for treating ore by a cyanide solution, a tiltable tank comprising a suitable support, a tank body having a discharge gate at its rear end and pivoted to the support at a point between its center and the front end, a drain device in the bottom of the tank for drawing off the cyanide solution, holding springs mounted on the support and engaging with the tank body at points between its discharge end and the pivotal connection thereof with the support, and means for retracting the holding springs from engagement with the tank body.

611935—October 4, 1898. J. Poole. *Process of and apparatus for treating ore tailings.*

For the continuous treatment of pulps, slimes, tailings, and the like with cyanide and similar solvent solutions and in combination, a series of shallow tray-like baths, a rake in each bath of the series, means for reciprocating the rakes, an overflow chute at the end of the series, settling tanks to receive the overflow from the chutes, means for separately discharging the solid and liquid contents of the tanks, conveyers adapted to raise the solid contents from one tank after discharge, a launder in which such contents are received and in which they may be further treated with a solvent solution or wash, and a further settling tank for receiving the discharge from the launder.

615968—December 13, 1898. T. Craney. *Apparatus for treating ores, etc.*

In an apparatus for treating ore, the combination of a tank adapted to contain a body of the ore to be treated, devices for feeding ore into the top of said tank and discharging it from the bottom thereof at a point above the tank in a continuous manner, a solvent supply reservoir, a receiver connections between the tank and said supply reservoir, and receiver for producing a continuous flow of the solvent through the tank in a direction opposite to that of the movement of the ore, an endless-chain carrier in proximity to the tank and having draining buckets adapted to receive the ore discharged from the tank, means for discharging a liquid upon the drainage buckets, and means for collecting the drainage from the buckets and returning it to the aforesaid supply reservoir.

617029—January 3, 1899. W. A. Köneman and W. H. Hartley. *Apparatus for separating liquids from solids.*

The method of abstracting liquid from finely pulverized ore, ore slimes, or other solids impervious to percolation with which the liquid is mixed, which consists in subjecting the mixture to gaseous pressure applied above the same, and simultaneously to the action of a partial vacuum applied below the same, removing a portion of the liquid by filtration below the body during compaction of the solids, and collecting and abstracting by pressure the remaining liquid above the compacted solids.

617497—January 10, 1899. P. ARGALL. *Cyanide filter tank.*

In a cyanide filter tank, a vertical metallic side or wall, a horizontal bottom secured thereto, having a central opening, a packing ring secured to the inside of said wall, near the bottom, with a spacing, a system of level joists converging from the perimeter toward the center, upon said horizontal bottom, a plastic filling between said joists sloping downward from the packing ring regularly toward the central opening, a level floor with interstices laid upon said joists, permeable filtering material upon said floor, and a covering of textile fabric, the outer margin of which is packed into the crevice between the packing ring and the vertical wall.

618622—January 31, 1899. P. SOMERVILLE. *Apparatus for extracting metals.*

An apparatus for extracting metals, consisting of parallel barrels having annular disks closing one end with central inlet openings for the material, a framework and roller support for said barrels, means whereby the barrels are rotated in opposite directions, spiral flanges fixed to the interior of the barrels for advancing the material therethrough, devices for feeding material and fluid matter to the uppermost barrel, means for separating the coarse from the fine material and delivering them separately, and means for transferring material from the discharge end of one barrel into the inlet end of the barrel below.

619211—February 7, 1899. A. M. NICHOLAS. *Filtering apparatus for separating gold and silver bearing solutions.*

This invention has been devised for the purpose of providing means whereby solids or insoluble material may be separated from liquids carrying same in suspension, but more particularly for the purpose of providing means whereby the separation of gold and silver bearing solutions from tailings, slimes, pug, or pulverized ore may be carried on continuously and in such a way that a clean or partially clean filter cloth will be continuously brought into operation without necessitating stoppages for recharging, as required with the appliances at present in use.

The essential feature of the invention consists in the use of a rotating wheel, disk, or table formed with a series of air-tight compartments covered with cloth or other filtering material supported upon a metal screen or perforated plate and adapted to be automatically placed in communication with a vacuum pump in turn for a sufficient time to enable the liquid to be drawn through the filtering material, leaving the solid constituents upon the filtering surface, whence they can subsequently be removed by brushes, jets of water, scrapers, or similar contrivances, provision being made for automatically allowing air to enter into the various compartments at the desired period of the operation to facilitate the removal of the solids from the outer surface of the filtering material.

620660—March 7, 1899. J. LUCE. *Apparatus for treating ores by lixiviation.*

In a tank for the treatment of ores, a lining composed of asbestos applied to the inner side of the tank, the notched or recessed boards applied inside of the asbestos, and the steam pipes placed in the notches in the boards, combined with two thicknesses of grooved perforated boards, and the layers of cloth between the boards.

623465—April 18, 1899. G. S. DUNCAN. *Apparatus for separating gold and silver bearing solutions from ores or slimes.*

Hitherto upward percolation has been used for the displacement of the various gold and silver bearing solutions in the treatment under the cyanide or other similar processes of tailings or free leaching ores which are not in the form of slimes. With this upward percolation false bottoms for the vats with webbing upon them have been used and the solutions have been introduced underneath these false bottoms, which have acted as distributers therefor and allowed them to pass evenly up through the free leaching ore, displacing the gold and silver bearing solution contained therein. This false bottom and webbing are adapted for use with free leaching ores only and can not be employed for displacing solutions used in treating very finely crushed ores or slimes which do not leach freely.

The present invention has been devised in order that the various solutions may be displaced, as above described, from finely crushed ore or slimes, without the aid of any false bottom and filtering-webbing. And the inventor claims, in an apparatus for separating solutions of the precious metals from residual ores and slimes, the combination with a leaching and displacement tank or vat and with a vat to hold said solutions, the latter being placed at a higher level than the former, of a series of pipes to convey said solutions from the higher vat, the discharge ends of said pipes entering the leaching vat, a series of hoods having slightly arched portions which overlie the said discharge ends, and stirring arms radiating from a central shaft in said vat, the arched portions of the hoods being arranged in radial lines, or at right angles to the movement of currents set up by the stirring arms.

623772—April 25, 1899. A. F. DUEY. *Apparatus for leaching ores.*

A device for treating pulverized ores, comprising a leaching tank, an air compressor, a tank for storing the leaching liquid, a perforated pipe in the bottom of the leaching tank, connections from the air compressor and liquid storing tank to the perforated pipe, a perforated drainage pipe in the bottom of the tank, and a layer of filtering material about said pipe.

624533—May 9, 1899. C. H. PEAD. *Slime filter.*

The apparatus consists of a tank fitted with a hood of conical or any other convenient form. The sides of the tank project above the point of attachment of the hood, so as to form an annular space to act as a receptacle forming a launder for discharge of the clear liquid. In the center of the hood is an opening, around which is riveted or bolted a frame or seating arranged to carry a filter composed of one or more layers of filter cloth or any other well-known filtering medium. The filter is kept in place by means of a protective gird or clamp of suitable form and strength to resist the effective pressure from the interior of the tank. A number of small distribution pipes set at such an angle as to cause the slimes to impinge on the under surface of the filter are connected to the seating of the latter, through which they pass. They are connected to a main distributer, which in turn is connected with the delivery pipe or column of the slime pump. One or more taper shaped plugs or cores constructed of light steel tubes, their number varying according to the size of the tank, pass through the hood and extend to the bottom of the tank. They taper from about 18 inches at the top to 15 inches at the bottom. They are fitted at their upper ends with a flange, to which is attached a shackle. Their lower ends are closed by means of a dished bottom riveted in place and having a strong bolt or stud fitted to its center. Each plug or core rests on a seating fitted to the outside of the hood and through which the plug or core passes. The seating is attached thereto by means of its flange.

In the bottom of the tank and directly under the aperture in the hood through which the plug or core passes is a discharge door of the ordinary manhole or other convenient type. The end of each plug or core passes easily into the discharge opening, and the discharge door is drawn up onto its seating or joint by means of the bolt or stud on bottom of the plug or core and by its nut. The plugs or cores when in place and holding up the manhole doors afford an effectual means of resistance against internal pressure.

A special pipe is arranged and fitted to the upper portion of the tank to drain the space forming a launder between the top of the tank and the upper surface of the hood and to conduct the liquid portion which has passed through the filter to the precipitation boxes or to waste.

624633—May 9, 1899. F. A. Edwardes. *Apparatus for use in treating metallic ores.*

In apparatus for use in the treatment of metallic ores, the combination with an annular vat having a stirrer moving therein and skimmers attached to and moving with the said stirrer, of means for tipping the said vat for discharging the contents.

624957—May 16, 1899. L. H. Mitchell. *Tank bottom discharge door.*

A discharge apparatus for tanks provided with a hollow upper portion, a base having integral bearing zones connected thereto at one end thereof, a casting having an upper annular supporting rim and adapted to receive said bearing zones, a ring surrounding said casting, devices connecting said rim and ring to secure the casting in position, and means supported by said casting to unseat said base.

624958—May 16, 1899. L. H. Mitchell. *Tank bottom discharge door.*

A discharge apparatus for tanks consisting of a casting secured in the bottom of the tank, a ring below the tank around the casting, and means for securing the rim and ring in position, a funnel above the casting, a base connected with the lower end of the funnel and provided with an annular offset or shoulder, a packing ring within the offset, and adapted to rest upon the rim of the casting, a plate or bar bearing against the rim of the casting, a nut carrying screw in the plate or bar adapted to engage the base and draw the same within the casting, a brace or clamp connected to the plate or bar above the nut on the screw, and means for rotating the screw.

639540—December 19, 1899. W. Duncan. *Means for mixing and aerating sands or tailings while under treatment by solvents.*

Numerous attempts have from time to time been made to secure the thorough mixing of sands and tailings, including slimes, with the solvent while under treatment and also to prevent that close packing which prevents the percolation of the solvent and wash liquors. For this purpose vertical vessels with vertical agitators, revolving barrels, and air, steam, and water jets have been used, but these means have not been as efficient as they might be.

This invention relates to improved mechanical means for mixing and aerating "sands" or "tailings," by which terms are included slimes, sludges, and concentrates, while under the action of solvents, whereby time is saved and a better extraction is obtained; and it consists of a semicircular vat provided with a revoluble agitator composed of arms arranged helically on a shaft running the length of the vat. At one end of the vat is placed the fast and loose pulleys and gear for slowing and rotating the agitator, while at the opposite end a series of taps are provided connected to the vat at various heights and to pipes, so that the liquor can be drawn off at any desired point and either run direct to the sump or through a filter to the sump.

641419—January 16, 1900. H. C. Wheeler. *Agitator.*

In an agitator, the combination of the vat, the track provided with the cog rack, the carrier provided with the pinion meshing with the cog rack, the first driving shaft provided with the driving pinion, the driven cogwheel meshing with the driving pinion, the gear wheels connecting the driven cogwheel with the pinion meshing with the cog rack, the agitator frame journaled or pivoted to the carrier frame, the second driving shaft journaled in the agitator frame, the agitators journaled in the agitator frame and adapted to be operated by the second driving shaft, intermediate gearing connecting the second driving shaft with the driven cogwheel, one of such gears being journaled with its axis in line with the axis of the pivotal support of the agitator frame, and means for rotating the first driving shaft.

647358—April 10, 1900. D. W. Balch. *Leaching tank.*

A tank having a bottom, a leaching false bottom above the same, and vertical filtering partitions arranged in pairs within the tank, whereby spaces are left between pairs of partitions, and other spaces are left between members of such pairs, said spaces last named all communicating with the chamber between the bottom and false bottom.

647678—April 17, 1900. C. W. Merrill. *Means for charging leaching vats.*

This invention relates to a method of charging ore or tailings to a leaching vat, which process is a step in the treatment of said ore or tailings preliminary to the application of the solvent solution in cyanide, hyposulphite, or other hydrometallurgical processes.

It consists, essentially, in conveying the tailings or ore by any well-known adaptable mechanical means to a point above the center of the vat to be charged and delivering the material there to a hopper, which feeds a revolving chute inclined at an angle greater than the natural slope of the material to be handled, and with openings adjustable both as to size and position, through which the material to be treated falls gently into the vat and distributes evenly, thus giving a charge of minimum density and maximum homogeneity, the conditions most favorable to successful leaching and dissolution of the precious metals.

The ordinary method of charging leaching vats is from cars running on a superimposed track. By this means the momentum of the carload of tailings or ore dropping through five or more feet to the bottom of the vat is such as to produce considerable packing, and, moreover, an uneven packing or density. For instance, in dumping from an end discharge car the resultant mass of ore or tailings will take the form of a cone in the vat and the maximum density will be in the center of the approximate circle forming the base of the cone and will decrease along the radii toward the circumference of this circle. Furthermore, the variation in fineness of the different carloads is not equalized, and a vat charge of ore or tailings results, which is heterogeneous, both as regards density and as regards fine and coarse material. Now, first, the charge of ore or tailings in a vat should be of the least density possible to obtain, because experience has demonstrated that the greater the permeability, and consequently the greater the amount of lixiviant possible to percolate through the charge, the greater the extraction of the precious metals in a given time, or, from another standpoint, the greater the permeability the less the economic period for leaching, and hence the less the cost for plant and subsequent operation; second, the charge should be as nearly homogeneous as possible as regards both density and size of material, because in leaching ores it is necessary to follow solution with wash water to replace and prevent the loss of the former or to follow one lixiviant with another of different strength or containing a different solvent, and in doing this to maintain the surface of demarcation between the one and the other as nearly a horizontal plane as possible in order to minimize the mixing of effluent solutions. The above conditions of minimum density and maximum homogeneity are produced by means of a revolving inclined wide chute with small openings in the bottom, adjustable as to size and position transverse to the direction of the stream of ore or tailings. By means of this method a number of very small streams of ore or tailings fall gently into the vat as the chute revolves, and by increasing the speed of revolution a carload of fine or coarse material can be spread over the whole area of the vat, thus giving the smallest possible dimension parallel with the course of the lixiviant.

653631—July 10, 1900. J. C. Wallace. *Filter barrel or tank.*

In a filter barrel or tank, a filtering device consisting of a series of curved metal plates, perforated, fastened to the inside wall or walls of said barrel or tank; a filter cloth upon the upper surface of said plates, secured thereon by a series of imposed metal bars and filling strips secured in position by bolts or other fastening devices to the wall or walls of said barrel or tank.

653684—July 17, 1900. F. H. Long. *Metallurgical filter.*

The combination with a closed vessel having a filter septum and a regulated outlet port for the filtrate beyond such septum, of the wash water pipe connected in hydrostatic column with said vessel and the external centrifugal pump joined at its separate sides in closed union with the opposite ends of the vessel, the journal box for said pump axle being furnished with a water column pipe to counterbalance the hydrostatic pressure at the vessel.

654315—July 24, 1900. T. E. LEECE. *Apparatus for working ores of valuable metals.*

This invention relates to an apparatus which is designed for working the ores of valuable metals, and is especially useful for separating slimes from solutions in which they may occur, and also for separating heavier and lighter parts under any condition in which they may be found associated.

It consists, essentially, of a tank and an endless traveling belt with directing rollers, by which one portion of the belt is caused to travel through the tank in close proximity with the bottom, and the other part is guided back exterior to the tank by similar rollers. It also comprises a means for straining or separating the liquid from the heavier portions.

660498—October 23, 1900. J. A. FLEMING. *Apparatus for leaching ores.*

In an ore leaching apparatus the combination with the leaching tank having a pulp discharge, of the conical perforated filtering hopper therein having the discharge for the pulp, means by which to maintain air pressure below the diaphragm, whereby to control the flow of solution through it, means for the introduction and withdrawal of chemicals to and from the body of the tank above the filtering diaphragm, and devices for controlling the discharge of the pulp from the tank.

660499—October 23, 1900. J. A. FLEMING. *Apparatus for leaching ores.*

An ore leaching apparatus, consisting of the leaching tank, having a filtering hopper, a solution discharge below said hopper, and a pulp discharge also below said hopper and independent of the solution discharge, a washing tank below the leaching tank and in position to receive the pulp from the discharge thereof, and means for controlling the passage of the pulp from the leaching to the washing tank.

664059—December 18, 1900. J. P. SCHUCH, Jr. *Ore mixing machine.*

Heretofore, in treating gold bearing ores by the common cyanide process, the ore is first crushed, dried, and rolled to a proper degree of fineness, and that which requires roasting is then conveyed to the roasters, while the oxidized ore which does not require roasting is conveyed to the bin or receptacle therefor. After the portions of the ore to be roasted have passed through this step of the process the same is conveyed to the cooling room before being deposited in the bin or receptacle referred to which contains the ore requiring no roasting. All of the ore is then removed by manual labor into the ordinary stationary cyaniding tanks, and after these tanks are filled with the ore the cyanide solution is introduced therein. In this process the filled cyanide tanks, with the solution and ore therein, are permitted to remain filled and unmolested for a sufficient length of time for the solution to act on the ore, after which the gold bearing solution is drawn off and allowed to flow to the precipitation room, while the tailings in the tank are then washed with water and shoveled out or sluiced out when this is possible. In this process, which is the one usually followed out in extracting gold and silver from their ores by the use of cyanogen containing solvents, the percentage extracted rarely exceeds 80 per cent of the ore value, and it is the purpose of the present invention to provide means whereby a larger per cent of the value of the ores may be saved.

To this end the invention contemplates an improved mixing machine which provides for a thorough aeration of the ore and solution, while at the same time providing for a mixing of various grades of ore with the cyanide solution, so as to make one even grade out of ores of various values. And the inventor claims, in an ore mixing machine, an open tank provided at the bottom with a solution drain, a perforated false bottom arranged within the tank above the main bottom and supporting filtering material, an ore discharge pipe communicating with the interior of the tank immediately above the plane of the false bottom, a revoluble agitator depending within the tank into close proximity with reference to the false bottom, and a plurality of air jets arranged to communicate with the tank in a plane intermediate the said false bottom and the lower end of the agitator thereabove.

664196—December 18, 1900. J. C. WALLACE. *Filter bed.*

In a filter barrel, a filter bed consisting of a series of metal plates having drain slots or perforations therethrough, a series of perforated tiles arranged as a filtering medium upon and supported by said metal plates, a series of metal binding strips imposed upon or against said tiles; together with suitable means for fastening or confining the same together and to the inner wall of a filter barrel or tank.

671028—April 2, 1901. J. R. PHILLIPS. *Pulp agitator.*

This invention consists of an inclined or funnel shaped tank or containing vessel into which the pulp is placed with water, cyanide solution, or other equivalent liquid, a circulating or suction and force pump by which the surface liquid may be drawn from the tank, and a pipe extending centrally down to near the bottom of the cone, with a discharge nozzle through which the liquid is delivered with force, so as to flow upward along the sides of the funnel and through the material, whereby the latter is loosened, agitated, and prevented from packing. In conjunction with this may be used a canvas or equivalent filter lining for the funnel, with means for providing a space intermediate between it and the sides of the funnel for the filtering through of water, and a means for conducting such filtered water away from the apparatus.

680154—August 6, 1901. A. D. JANSEN. *Discharge door for cyanide tanks.*

In cyanide treatment the sands are subjected to the action of cyanide solution, which solution after the proper length of time has elapsed is drawn off through a filter composed of matting or some similar material situated at the bottom of the tank. This matting or filtering material does not rest directly on the bottom of the tank, but is supported by a grating or perforated false bottom in order to allow a free passage for the solution which has filtered through. That portion of the tank, therefore, which is situated over the discharge door has no grating or filtering material, and consequently a more or less vertical column of sand is left in the tank, which still contains cyanide solution with gold in solution, the result being that this portion is imperfectly treated.

The object of this invention is to provide a door so constructed that a piece of matting or filtering material may be placed upon it in order that the filtration of the solution shall be just as complete over the discharge door as in the rest of the tank.

This invention furthermore relates to an improved construction whereby the door is rendered much more easily closed and also to a system of packing the same by which the joint between the door and the bottom of the tank is rendered tight.

683412—September 24, 1901. A. J. PERRY. *Ore separator.*

The object of this invention is to introduce a mixture of steam and air in the pulp, whereby the precious metal receives a quick chemical action, with the result that considerable time is gained over the method heretofore employed. And the inventor claims, in a leaching apparatus, the combination of a receptacle for holding pulverized ore, an agitator mounted in said receptacle and having a series of radial horizontal pipes each provided with a series of perforations at one side thereof, a series of scrapers or blades mounted on said agitator, a pipe adapted to supply to said agitator a mixture of steam and air from a proper source, and means adapted to rotate said agitator whereby the discharge of steam and air through the perforations of said pipes is directed toward the rear while the said scrapers or blades are moving in the opposite direction.

684654—October 15, 1901. C. Voelker. *Ore filter.*

The extraction of valuable metals from ores through the lixiviation processes, such as the cyanide and others, although allowing the advantageous working of low-grade ores, still has one fault, that more or less metal remains in the tailings, and thus losses occur caused by the slimy particles contained in the pulverized ores generated from clay, talc, and other minerals which clog up the meshes of the filtering cloth, and thus prevent the solution from going through freely. In such apparatus the ore is introduced and the solution added, and where it happens that the ore lies in different grades of value inside the tank, the solution can not dissolve the metalliferous particles in an even manner, and at the same time where it enters first it will affect the pulp more thoroughly, and as it goes down to the bottom will take the slimes forming with it, depositing them around the aperture through which the solution is drawn off, and even several after leachings will not remove them. To overcome these drawbacks it is necessary to construct a mechanical apparatus which shall possess the condition of letting the soluble liquids needed to dissolve the metals go through the pulp in a space of time to be governed by the operator. Some ores are liable to contain chemical substances retarding the effectiveness of the soluble agent used, and where it is of great import to remove them as quickly as possible to keep them from going into chemical action with the solution used.

The object of this invention, therefore, is to combine the abovementioned conditions, and the apparatus can be used, in addition to other milling plants, to receive the tailings direct from the mill. The filtrate can be examined in regard to the valuable mineral matter which may exist, giving the metallurgist the means of saving the valuable salts of mercury, copper, silver, gold, and the like which may form through the chemical or electrical action in the amalgamators where such are used and where the extravagant use of copper sulphate, mercury, and salt is in most cases the cause of the solubility of gold.

The inventor claims: An ore filter, comprising a funnel shaped tank, a basket or filter holder removably arranged in said tank and fitting closely against its inner wall, a filtering textile stretched over the inner surface of said basket, a top or hood for the tank, a shaft extended downward in the tank, and a screw mounted on said shaft and spaced at its inner edge therefrom, the said screw having the end of its upper turn turned downward.

687920—December 3, 1901. A. D. Jansen. *Apparatus for charging or discharging cyanide vats, etc.*

In combination, the pair of tanks situated one above the other, stirring mechanism for said upper tank, having a hollow supporting or operating mechanism, and stirring mechanism in said lower tank, having its operating mechanism in line with the hollow mechanism of the upper tank, and means for raising said operating mechanism of the lower tank into said hollow mechanism of the upper tank.

688085—December 3, 1901. A. G. Goldsobel, W. Muttermilch, and C. Jablczynski. *Apparatus for the recovery of precious metals from photographic residuum.*

The combination with a vessel having a loose lid, a spout or outlet for the outflow of liquid and a conical bottom and with a precipitating material contained in said vessel, of a tube having a funnel shaped end reaching within said vessel, and of a second tube provided with a cock connecting the aforesaid precipitating vessel and funnel shaped tube with a second vessel or receiver.

689799—December 24, 1901. R. L. Graves. *Ore leaching apparatus.*

The apparatus for use in extracting ores, consisting of a plurality of tanks, a pump, a discharge pipe leading from said pump and having a plurality of branches leading to the several tanks and provided each with a discharge pipe which may be turned axially or swung vertically, valves controlling the several branches, and a flexible supply or suction pipe leading to the pump and arranged to be shifted from tank to tank, levers connected with the several discharge pipes whereby they may be turned axially, and means connected with the lower ends of the discharge pipes whereby they may be swung vertically.

690375—December 31, 1901. G. Rubsch, Jr. *Agitating machine for cyaniding.*

An agitating machine for the treatment of gold and silver ore by the cyanide process, comprising an agitating tank, having a conical bottom; a heating chamber surrounding the conical bottom of the agitating tank; means to heat said chamber; a rotary pump, centrally disposed in the agitating tank, adapted to take the solution from the bottom of the tank and discharge it above the top thereof; a rotary deflector, adapted to distribute the solution over a stationary deflector; and a stationary deflector affixed to the casing of the pump, adapted to deflect the solution to near the edge of the agitating tank.

691706—January 21, 1902. F. H. Long. *Metallurgical filter.*

The combination of a vessel having a conical filter-septum and an outlet-port for the filtrate beyond such septum, of means for establishing an end-to-end circulation of the vessel contents above said septum, a conical spreader and an oppositely facing conical baffle plate having a projecting spiral flange successively interposed between the ends of the vessel and arranged adjacent to said conical filter-septum to intimately direct such circulation over the surface thereof.

697178—April 8, 1902. E. L. Sharpneck. *Apparatus for the treatment of ores.*

As a means for facilitating the dissolving of the values in ores, the combination of a leaching tank, a conduit leading from and discharging directly into the tank, and means in the conduit connected with a heating medium supply for agitating, circulating, and heating the liquid contents of the tank.

698016—April 22, 1902. J. J. Hervey. *Cyanide tank.*

Cyanide tank having a tapering bottom and a central cone arranged in connection with the bottom, an annular lining arranged in the tank and open at its lower end, a filtering screen connecting the lower end of the lining and the central cone, the air and water pipes, the charging and discharging pipes, and the forcing means connected with said pipes.

699211—May 6, 1902. De W. C. Mosher. *Barrel filter.*

The combination with the lead lining of a filter barrel, of filter sections or plates having projections on their outer sides and perforations through the plates between the projections, and having bent ends, whereby the plates may be united to the lining by burning.

699212—May 6, 1902. De W. C. Mosher. *Barrel filter.*

The combination with the lining of a filter barrel, of perforated filter sections, and means for supporting said sections and securing them to the lining, said sections having their adjacent ends so constructed and arranged to form a longitudinal channel.

701239—May 27, 1902. F. D. Wood. *Means for working ores by the cyanide process.*

An apparatus for treating ores consisting in combination of a plurality of aligned containing tanks, a transversely concaved endless belt passing through and returning beneath each of said tanks, and upon which the ore is carried, each of said belts discharging its load upon the belt of the next succeeding tank, means for driving said belts in unison, means by which said belts are kept transversely distended and rollers disposed at intervals in said troughs and over which the belts pass, whereby the latter are given an undulatory movement.

702064—June 10, 1902. F. H. Long. *Metallurgical filter.*

In metallurgic filters, the combination with the closed perforated tank having an internal fabric septum with stretcher frame therefor to rest against the tank walls of the feed pipe leading into the tank bottom and the separate wash water pressure tube united to said feed pipe between the inlet and outlet valves thereof.

702490—June 17, 1902. R. SEEMAN. *Apparatus for treating copper ores.*

A plant for the treatment of ores, comprising a safety vessel, a mixer revolubly mounted, a settler revolubly mounted at a lower level than the mixer, and a still revolubly mounted at a lower level than the settler, and pipes connecting the several vessels together, the portions of the several vessels and pipes with which the ammoniacal solution of copper comes in contact being of material indestructible by such solution.

705589—July 29, 1902. A. JAMES. *Apparatus for precipitating gold and silver from their solutions.*

In the precipitation of gold and silver from cyanide and other solutions zinc is usually employed as a precipitant, and the use of iron vessels containing the solutions has been found objectionable, because the iron being electro-negative to zinc a galvanic action is set up between the vessel and the zinc, which causes the precious metal to be deposited upon the vessel instead of upon the precipitant. Owing to this difficulty the general practice has been to use vessels constructed of wood or earthenware, which are inconvenient and do not facilitate the cleaning-up operation.

The object of this invention is to avoid these objections.

To this end the invention consists in a metallurgical filter for separating precious metal from a solution containing it, consisting of a metallic vessel and a zinc sponge disposed therein, said vessel having an inner coating of enamel, whereby galvanic action between the metallic vessel and the zinc is prevented and deposit of precious metal on the vessel avoided.

705726—July 29, 1902. J. C. WALLACE. *Filter bed.*

In a filter bed, the combination of a corrugated filter sheet or blanket having numerous perforations through the lower arcs of said corrugations; a series of transverse supporting bars formed to fit under and receive the corrugated contour of said filter sheet; a series of superimposed binding strips or bars with transverse corrugations and slotted ends; two longitudinal side binding strips or bars, and bolts adapted to holding the several members together and in place within a filter barrel or tank.

706334—August 5, 1902. G. MOORE. *Apparatus for leaching ores, etc.*

In dissolving the soluble portions of ores, furnace products, and other like materials it has always been difficult in one operation to dissolve the final traces of the soluble portions and at the same time completely utilize the dissolving power of the acid alkali. The weakening of the acid or alkali by its dissolving action makes its action less energetic toward the finish of the operation at the very time when the more difficult soluble particles needing the most energetic dissolving action are acted upon. This not only causes loss of reagent, but also further loss on account of the poor extraction of the soluble elements desired. Also, in the case of ores of a talcose or slimy nature the talcose portions in the form of slimes prevent percolation of the solutions in tanks by clogging. These slimes should be separated and filtered separately by known methods. Then the remaining portion will easily allow percolation.

The object of this invention is to provide an improved apparatus for the purpose of overcoming these difficulties; and with this object in view the invention consists, primarily, in a hollow truncated cone mounted to rotate about a central horizontal axial line, provided with an opening at one end to receive the material to be acted upon, an opening at the opposite end to receive the fluid solvent, means for actuating the material through the cone in one direction and means for actuating the fluid solvent through the cone in the opposite direction simultaneously with the passage of said material.

706472—August 5, 1902. A. E. JOHNSON. *Filter bed for chlorination barrels.*

The combination with a chlorination barrel or tank of a filter bed placed therein and composed of a series of bars placed side by side and having grooves in their sides forming spaces for filtering material, the corners of the bars being cut away to permit insertion of the filtering material after the bars are placed side by side, and binding strips located at the ends of the bars and covering the filling openings, the said strips being secured to the barrel to hold the filter in place, an outlet being formed in the barrel below the filter.

708494—September 2, 1902. J. RANDALL. *Apparatus for extracting metals from ores.*

In an apparatus for treating ores, the combination of a series of tanks with a series of agitators above said tanks and discharging into the same, so arranged that the overflow of the solvent fluid from each tank discharges into the agitator over the next adjacent tank and from thence into the latter, and means for conveying the ore from the bottom of each of said tanks into the agitator directly above the adjacent tank for discharge into the latter.

709135—September 16, 1902. J. BROWN. *Ore leaching apparatus.*

An apparatus for leaching ores, comprising a tank adapted to contain water or other liquid, a conduit connected to and extending upwardly from the tank and having the plurality of chambers, a hopper disposed above the upper chamber, ball valves for controlling the discharges of the chambers and hoppers, electro-magnets disposed above the valves and adapted when energized to raise the same, the hoods and deflectors arranged in the chambers and hopper above the electro-magnets, an electro-generator, a movable commutator and circuit wires connecting the magnets generator and commutator, the said commutator being adapted to change the circuits and the condition of the magnets.

709593—September 23, 1902. D. C. BOLEY. *Apparatus for treating pulverized ores of gold or silver.*

The difficulty which has been experienced in treating finely divided ores by filtration with a cyanide solution is well known. In the case of battery slimes, which are produced by crushing the ore in the battery in the presence of either water or a cyanide solution, and equally in the case of the fine dust which is produced by dry crushing and which becomes a slime by the addition of moisture, the difficulty in all these arises when attempt is made to filter the material, so as to draw off the moisture, because the slimes collect upon the surface of the filter, and when this collection reaches a certain thickness the fluid will no longer pass through and the filtering surface must then be cleaned, and this difficulty begins very soon and constantly increases as the filtering proceeds. Attempt has been made to overcome this to some extent by producing a vacuum at the delivery side of the filter, and also an attempt to facilitate the filtration by creating an air pressure on the other side of the filter; and it has been attempted to prevent the collection of this impervious coating of filtrates by stirring and agitating the contents of the filter. So far there has been no organized apparatus capable of carrying on this work of filtering slimes successfully and economically, and such an organized apparatus is the object of the present invention, which consists in a revolving filter cylinder having vacuum chambers and means for supplying air pressure, the filtering surface being arranged in cylindrical form inside of the vacuum chambers, and the mode of operation being to agitate the pulverized ore by revolving the cylinder and by the pressure of compressed air and dissolving the gold and the silver in the presence of a solution of potassium cyanide and of the oxygen derived from the compressed air and the removal of the solution containing the gold and silver by filtration, assisted by the vacuum, and the continuous removal of the filtrates from the surface of the filter by their own gravity in the turning of the cylinder and the further cleaning of the filter surface by a backward blast of compressed air applied after the filtering therethrough ceases.

710462—October 7, 1902. R. D. JACKSON. *Settling tank.*

In a settling tank, a distributer having downwardly extending discharge outlets for pulp and liquid, means for supplying material to said distributer, means for rotating said distributer, and means for raising said distributer while rotating, whereby the distributer rises steadily above the accumulating deposit.

710495—October 7, 1902. S. T. MUFFLY. *Apparatus for treating ores.*

An apparatus for treating ores, comprising a rotary cylinder, air inlet and outlet pipes connected therewith at opposite ends thereof, automatic valves oppositely directed and controlling the inlet and outlet pipes, means for forcing air through the said inlet pipe, means for heating the said air, a solvent container connected with the air inlet pipe whereby the solvent is forced by and with the air into the rotary cylinder in the form of a spray, means for governing the amount and pressure of air and of the solvent, devices within the cylinder for scattering and agitating the ores as the said cylinder is revolved.

711236—October 14, 1902. H. SMITH and P. C. BROWN. *Apparatus for use in extracting precious metals from their ores.*

In a lixiviation apparatus, a revoluble tank, pipes conducting a solvent, air, and steam to the tank, means for rotating the tank, and a pipe in the end of the tank opposite the end containing the supply pipe.

712963—November 4, 1902. J. J. PRINDLE. *Barrel filter.*

In a chlorination barrel filter, a platform comprising a series of perforated members or sections having the end portions thereof thickened or enlarged, said enlarged portions provided on their lower sides with prolonged curved faces forming supporting heels which conform to the curvature of the barrel in which the filter platform is adapted to be used, and bolts passing through said curved heels and cooperating therewith in holding the platform in place.

713694—November 18, 1902. J. P. SCHUCH, Jr. *Ore mixing machine.*

An ore mixing machine, comprising the following elements: An ore mixing tank, a false bottom including a strainer, means for discharging air beneath the strainer to keep the meshes thereof free from any accumulation of slime or the like, air supply pipes disposed above the strainer to effect aeration of the contents of the tank, a track carried by the upper outer portion of the tank, an agitator shaft having its upper portion polygonal in cross section, a spider having a hub engaging the said polygonal portion and carrying traveler wheels at its extremities to engage the track, agitator bars suspended from the spider, and beaters or stirrers carried by the bars, each set of beaters being disposed in break-joint order with relation to the adjacent set of beaters.

714822—December 2, 1902. J. RANDALL. *Settling tank or decanting vessel.*

A settling tank, consisting of a body having a vertical side and a bottom formed of slopes of different inclinations and provided with a central outlet, the said side having a cutaway portion forming an overflow lip, a launder encircling said lip and provided with a discharge spout, a baffle plate of cylindrical form connected by strips to the upper portion of said side and extending into the tank below the top and nearly to the lower edge of said side, and a pipe leading from said central outlet.

718680—January 20, 1903. B. TULLY. *Barrel filter.*

A filter, comprising a rotatable barrel, provided with a lead lining, the body of the barrel being provided with apertures and the lining being perforated opposite said apertures, a lead launder arranged on the exterior of the barrel and provided with a plurality of lead branch pipes, said branch pipes at their inner ends being fitted in said apertures and connected to the lead lining about said perforations.

719273—January 27, 1903. Z. B. STUART. *Apparatus for treating ores.*

A tank having an open top and a concave bottom formed of perforated removable plates, a removable, conical plate upwardly projecting from the center of the bottom, a perforated box under said conical plate, a layer of coarse fabric surrounding said perforated box, a filtering material under said perforated plates, a pump, a suction pipe extending from said pump to and through the mixture in said tank to a point adjacent to the upper surface of the mixture, and a discharge pipe extending from said pump to a point adjacent to the conical part in said tank, a vacuum tank, a pipe connecting said vacuum tank to said perforated box, and a suction pump connected to said vacuum tank.

719664—February 3, 1903. J. B. HEFFERNAN. *Chlorination barrel.*

In a chlorination barrel, a parallel series of pipes having numerous small orifices through their longitudinal walls, one or more headers adapted to receiving the ends of said pipes, a valve or valves connecting said header or headers with an outside source of fluid pressure.

719756—February 3, 1903. S. C. C. CURRIE. *Mechanism for mixing and storing liquids and gases for ore treatment.*

In combination, an alkali mixing tank, an alkali stock tank at a lower level and connected by a pipe thereto, a mixing chamber at a level below the alkaline storage tank, said mixing chamber having inclines leading from opposite sides, a chlorin gas supply pipe leading from above the top of the mixing chamber into the bottom thereof, a storage tank for chlorinated liquid below the level of the mixing tank, and a gas supply pipe leading from the top of the mixing chamber nearly to the bottom of the storage tank.

722314—March 10, 1903. L. H. MITCHELL. *Discharge means for tanks.*

A discharge apparatus for tanks, provided with a casting having an upwardly projecting rim provided with shoulders having longitudinally inclined underfaces, a funnel having a base provided with a depending offset portion, a gasket mounted in the recess formed by said offset portion and adapted to seat upon the top of the rim, lugs formed on the depending portion and provided with longitudinally curved upper faces to engage the inclined faces of the shoulders, and operating handles at the top of the funnel.

722399—March 10, 1903. H. R. CASSEL. *Barrel filter.*

A barrel filter composed of a barrel having a lead lining, and of a filter having rigid cores and surrounding lead casings made integral with the lining.

725549—April 14, 1903. H. R. ELLIS. *Centrifugal lixiviating machine.*

In a centrifugal filtering machine, the combination of a rotary shaft, a drum mounted thereon, a perforated partition within the drum, arranged concentrically with the periphery of the drum at such distance therefrom as to form an annular chamber about the perforated partition, means for supplying liquid to the annular chamber, a discharge opening in the bottom of the drum, a cover therefor adapted to be held open by centrifugal force when the drum is rapidly rotated to permit discharge of the charged liquid, and to be held in closed position when the drum is rotated slowly, and a discharge gate in the bottom of the drum at a point nearer the center than the discharge opening.

727230—May 5, 1903. F. G. UNDERWOOD. *Leaching tank filter.*

The apparatus consists of a tank having a central discharge aperture provided with a movable closure, an interior filter diaphragm spaced from the bottom of the tank and having a central discharge aperture registering with the tank discharge aperture and provided with a movable closure, in combination with vertical filter members radially disposed and spaced apart between said discharge apertures and the walls of the tank and communicating with the space beneath the diaphragm.

727362—May 5, 1903. H. HIRSCHING. *Apparatus for treating ores.*

An ore treating apparatus including a leaching vessel, a settler, a filter, a still, a condenser containing a coil, a stock solution tank, and an absorption tank, said absorption tank consisting of an outer casing communicating with a cooling water tank, an inner casing spaced from the outer casing and communicating with the stock-solution tank, and an innermost casing spaced from the inner casing and communicating with the coil of the condenser, whereby the vapors and fluid emerging from the coil are caused to flow through the innermost casing and through the absorption water, and the absorption water is caused to flow through the inner casing to the stock solution tank, said parts being connected together by means of pipes.

728126—May 12, 1903. P. W. MCCAFFREY. *Precipitating apparatus.*

In precipitating apparatus, the combination of a tank having curved walls, said tank being adapted to hold the solution to be treated and being provided with a central partition around the extremities of which the liquid is free to circulate, blocks or pieces made fast to the opposite sides of the tank, their inner surfaces being parallel with the surfaces of the partition, and cylinders mounted to rotate on opposite sides of the partition and partially immersed in the solution, said cylinders being perforated and containing scrap iron, the ends of the cylinders being located as close to the partition and the said blocks as is practicable in order to allow perfect freedom of movement, and means for rotating the cylinders in reverse directions whereby the liquid is set in motion in a circular current.

728746—May 19, 1903. P. W. MCCAFFREY. *Means for precipitating dissolved metals.*

In precipitating means, the combination of a tank adapted to hold the liquor from which the precipitation is to be made, a number of perforated cylinders containing scrap metal, said cylinders being mounted to rotate in said tank which is constructed to receive solution at one end and discharge it at the opposite end above the lowest part of the cylinders, the latter being arranged in successive order from the feed to the discharge extremity of the tank and partially immersed in the solution, and suitable means for producing a current of liquid through the tank from end to end, whereby the contact of the liquid with the scrap metal in the tanks is facilitated.

729805—June 2, 1903. J. STOVEKEN and L. STOVEKEN. *Apparatus for extracting metals from ores.*

In an apparatus for extracting precious metals from their ores, the combination of a tank for containing a cyanide or other suitable solution, means for reducing ore to a finely divided or comminuted state, one or more conduits connected with the solution tank and arranged to supply the ore with solution incident to the reduction thereof, means for agitating and mixing the ore and solution, arranged to receive the same from the reduction means, a filter arranged to receive the ore and solution from the agitating and mixing means, and adapted to separate the solution from the ore, one or more decanting tanks arranged to receive the solution or solutions from the filter, a precipitating tank which receives the clear solution from the decanting tank or tanks, and means for transferring the solution from the precipitating tank back to the solution tank.

729806—June 2, 1903. J. STOVEKEN and L. STOVEKEN. *Agitation tank.*

The combination of a tank, a central, vertical cylinder arranged therein, a piston movable in the cylinder and having a rod extending through the upper head thereof, a gear disposed above the tank and adapted to be connected by a driving connection with a motor, a shaft stepped on the piston rod and keyed to and adapted to move vertically through the gear, wings connected to and extending inwardly from the vertical wall of the tank, agitating means carried by the said shaft and surrounding the upper end of the cylinder, and comprising a head fixed on the shaft, blades disposed below the wings and connected together, said blades being curved in the direction of their length and inclined in the direction of their width, connections between the outer portions of the blades and the head on the shaft, connections between the inner portions of the blades and said shaft, and a pipe communicating with the cylinder below the piston and adapted to be connected with a source of fluid pressure supply.

730195—June 2, 1903. J. STOVEKEN and L. STOVEKEN. *Metallurgical filter.*

In an apparatus for extracting precious metals from their ores, the combination of a filter comprising a frame, an endless filter cloth, means for driving same, means for pressing pulp against the upper stretch of the cloth at different points and separate receptacles arranged below the cloth at such points, and a decanting vat having separate tanks connected with the said separate receptacles of the filter; the said separate tanks communicating with the vat at their upper ends, and having valved discharges at their lower ends.

730384—June 9, 1903. W. H. MOTTER. *Agitating apparatus.*

The combination of a rocking platform, means for operating the same, a frame mounted to reciprocate adjacent to the platform, cylindrical tanks or vats trunnioned on the frame and engaging the platform, flexible devices connected with the opposite extremities of the frame, guides therefor, a liquid containing tank, a piston therein, stems protruding from the opposite extremities of the tank, and a valve controlled conduit connecting the opposite extremities of the tank, the flexible devices of the frame being connected with the piston stems.

730385—June 9, 1903. P. W. MCCAFFREY. *Apparatus for the precipitation of metals from solutions.*

In apparatus for the precipitation of dissolved metallic values, the combination of a tank adapted to hold the solution to be treated, and a perforated receptacle containing scrap metal, the perforated walls of the said receptacle being composed entirely of the same material, said receptacle being partially immersed in said solution and mounted to rotate therein, whereby the solution is made to circulate through the scrap metal for the purpose set forth.

732720—July 7, 1903. H. DUNCAN and R. R. SHERRIFF. *Apparatus for separating liquids from solids.*

A machine for separating liquids from solids, comprising in combination a framing and gear, carrying and traversing an endless band of filter cloth, automatic slip devices for securing the band, a vacuum box or suction chamber located upon the under surface of said band, and an interposed endless band of wire cloth or gauze arranged to support and travel with the filter band.

733739—July 14, 1903. F. H. OFFICER, R. H. OFFICER, J. H. BURFEIND, and J. W. NEIL. *Apparatus for use in metallurgical processes.*

In an apparatus for treating ores or other materials containing gold or silver or other metals by the cyanide process, the combination of a treating tank, an absorption tank containing a caustic solution, a compressor and connections as described between the compressor, treating tank and absorption tank whereby air or gas under pressure may be forced from the compressor through the material in the treating tank and the gases released or freed from said material may be passed through the absorbing solution in the regenerator tank and thence to the compressor, so as to permit the air to be used over and over and the valuable products released in the treating tank to be recovered, as and for the purpose described.

735206—August 4, 1903. L. P. BURROWS. *Mixing and dissolving apparatus.*

A mixing and dissolving apparatus, comprising a containing vessel, a shaft in and movable relatively to said vessel, an inner and an outer set of stirring plates carried by and arranged around and substantially parallel to said shaft, the adjacent plates of the inner and outer sets converging toward each other from their front to their rear edges, and stirring blades secured to the rear edges of said plates and arranged in a spiral line around the shaft, the corresponding blades of the outer and inner sets being twisted in opposite directions.

735834—August 11, 1903. L. B. Skinner. *Filter.*

A filter bar, consisting of a body portion and separated tongues projecting laterally therefrom and recessed for the passage of filtering fluid, each tongue with a beveled end, and beveled faces on the body between the tongues.

735835—August 11, 1903. L. B. Skinner. *Filter.*

The combination in a filter bed, of bars having each a body portion and a perforated side flange with a beveled edge, and a beveled face constituting the bearing of the flange of the adjacent bar.

735960—August 11, 1903. G. S. Foster and S. S. D. Stringer. *Metal-extracting and ore-lixiviating apparatus.*

The combination of a solution-supply tank, a series of intercommunicating leaching tanks adapted to receive solution from said supply tank, drainpipes leading from said leaching tanks, a launder into which said drainpipes are arranged to discharge, and a charcoal box connected to said launder.

736036—August 11, 1903. H. L. Sulman and H. F. Kirkpatrick-Picard. *Apparatus for the recovery of precious metals.*

In an apparatus for recovering precious metals, the combination of a conical vessel having an inner amalgamated copper surface, a conical body having an outer amalgamated copper surface disposed concentrically within the vessel and forming therewith a narrow interspace, a body of mercury charged with an electropositive metal in the interspace, an electrolytic vessel for charging the mercury, a mercury pump, an inlet conduit to the top of the interspace from the electrolytic vessel, an outlet conduit for mercury from the bottom of the interspace to the pump, a conduit from the pump to the electrolytic vessel, an inlet conduit at the bottom of the vessel for the solution carrying the values, a nonreturn valve in said conduit, means for forcing the solution up through the interspace, and a launder at the top of the vessel to receive the discharged solution.

736078—August 11, 1903. H. T. Durant. *Apparatus for the treatment of ores with solvents.*

A device for the treatment of ore, tailings, or other material by solvents, consisting of a tank having a conical bottom, a plug in said bottom and made conical to correspond to the angular walls thereof, a pump or forcing device discharging into the apex of the cone, and a return connection between the upper part of the tank and the suction of the pipe.

736597—August 18, 1903. C. D. Grove. *Barrel filter.*

In a barrel strainer, the combination with the shell thereof of a strainer the exterior surface of which is in contact with the barrel, its inner surface being provided with suitable straining perforations in the form of slits combined with transverse grooves beneath the interior surface and establishing communication between said slits and the discharge opening.

737046—August 25, 1903. J. B. Truitt, W. L. Truitt, and W. O. Temple. *Precipitating zinc box.*

In a precipitating zinc box, the combination of an outer imperforate box having a valved outlet in its bottom and a valved outlet above its bottom, a launder at each outlet, and an inner removable zinc holding box having a perforated bottom, and supported in the outer box above the bottom of the latter.

737533—August 25, 1903. E. L. V. Naillen. *Apparatus for extracting gold and other metals from ores.*

In an apparatus for extracting metals from ores, the combination of a concentrating tank consisting of two cone shaped sections secured together at their largest diameter by means of suitable flanges and provided with an intermediate strip secured between said flanges and projecting outwardly, a settling tank disposed around the concentrating tank, a perforated diaphragm placed between the concentrating and settling tanks and supported upon said intermediate strip, and a suitable bracket bolted to the settling tank and adapted to form two horizontal sections within the settling tank.

738148—September 8, 1903. J. B. de Alzugaray and W. A. Mercer. *Apparatus for extraction of precious metals from their ores.*

Apparatus for treating ores, consisting of a closed containing vessel or vat provided with fixed internal blades or wings, a rotating hollow spindle provided with ball bearings and having hollow blades or beaters set at an angle, means for raising and lowering the spindle in the vat, gearing for rotating the spindle, and means connected with the vat for supporting the gearing and steadying the spindle, all combined, arranged, and operating as shown and described and for the purpose set forth.

738329—September 8, 1903. W. E. Holderman. *Device for treating slimes.*

In a device for treating slimes having a liquid-tight case, a discharge pipe provided with a valve in its bottom, an inclined floor in said case, spaced bars on said floor and the sides of the case, a filtering fabric covering said bars and overlapping the upper edge of the tank, a molding to hold the fabric in operative position, and pipes provided with stoppers leading from the filter out through said case.

740193—September 29, 1903. E. D. Sloan. *Barrel filter.*

In a barrel filter, the combination with the barrel of a partial lining of porous filter blocks fitting closely together and having grooves formed on their undersides which interconnect from block to block and form drain channels; means for sealing said draining channels from the inner space of the barrel, and a discharge port leading from the drains out of the barrel.

741189—October 13, 1903. H. H. Thompson. *Apparatus for extracting precious metals.*

An apparatus for extracting precious metals, comprising a receptacle provided with an outlet, a series of bodily movable and loosely mounted agitating arms gradually decreasing in length and adapted to be retained in their operative position when rotated in one direction and to assume an inoperative position when moved in an opposite direction, a rotatable means for suspending said arms within said receptacle, said rotatable means and arms bodily movable, a series of screened nozzles communicating with said receptacle, means for supplying a cyanide solution, compressed air and water to each of said nozzles either separately or in any preferred combination, operating means for said rotatable means, and means communicating with said supply means and the said outlet for exhausting the solution from said receptacle.

741402—October 13, 1903. W. E. Holderman. *Leaching tank.*

In a filtering tank having vertical slats covered with a filtering fabric, a filtering partition extended across said tank, a trough in its bottom for the filtrate, and an orifice through the filtering fabric of said tank into which the filtrate from said trough is discharged.

741499—October 13, 1903. A. E. Johnson. *Barrel filter.*

In a barrel filter, the combination with a suitable barrel or cylinder, of a filter having a perforated bottom, side walls extending below the bottom and engaging the barrel on the inside, filtering material resting on the bottom and confined by the side walls, a top perforated plate, and suitable means for securing the filter in place, a channel being formed underneath the bottom of the filter to receive the filtered liquid, the barrel being provided with a valved outlet in communication with the said channel.

743550—November 10, 1903. J. A. Ogden. *Process of extracting metals from cyanide solutions.*

The process of treating gold, silver, or other metals from a cyanide or primary solution, consisting in mixing in a receptacle a given quantity of said primary solution with a given quantity of a secondary solution having a metal base and capable of liberating the metals in said primary solution; leaving said mixture in said vessel until said liberation is partially effected, then passing said mixture into a second receptacle and agitated therein so as to produce a complete commingling of said solutions, from thence running the mixed solution into a settling tank and allowing it to settle, drawing off the clear solution, and then drying the precipitation and pressing and melting it into bullion.

743551—November 10, 1903. J. A. OGDEN. *Apparatus for extracting precious metals from cyanide solutions.*

An apparatus for the purpose set forth, consisting of primary and secondary solution tanks, each provided with discharge pipes with controlling cocks, and measuring glasses; a mixing vessel adapted to receive the flow from said measuring glasses; a barrel, with rotatable blades therein, and having a glass gauge on the outer face thereof, and a settling tank adapted to receive the discharge from said barrel.

745472—December 1, 1903. W. H. ADAMS, Jr. *Apparatus for treating ores.*

The combination of a tank, a box, a pipe at the top of the tank connecting the same with the box, a pump connected with the box, and nozzles connected with the pump and arranged to discharge liquid into the tank at intervals tangentially in an approximately horizontal plane.

746867—December 15, 1903. DE W. C. MOSHER. *Chlorination barrel.*

A chlorinating barrel provided with a resistant lining and with an arched channeled rib extending longitudinally, secured to said lining and having perforations between the interior of the rib and barrel, and a discharge opening communicating with the interior of the rib.

748088—December 29, 1903. G. MOORE. *Filtering system.*

In a filtering system, the combination with a tank for containing the material to be filtered and a cleansing fluid tank, of a filter, means for introducing and removing the same into and from each of said tanks alternately, means for drawing the contents of said tanks through the filter, and means for cleansing the filter.

748217—December 29, 1903. C. H. RIDER. *Apparatus for dissolving organic or inorganic substances.*

A device consisting of an acid tank, a water tank, an upper series of tanks connected with the acid tank and the water tank and to each other, a lower series of tanks adapted to receive the substance to be treated, connected to the upper series of tanks and to the water tank and to each other; a retort, means for heating the retort, a pipe passing from the retort through the lower series of tanks, and a condenser into which the last-named pipe extends, substantially as and for the purposes specified.

748462—December 29, 1903. W. J. ARMBRUSTER. *Chlorination barrel.*

A chlorination barrel having a pulp chamber and a chlorine generating compartment rotatable therewith, a wall separating the pulp chamber from the compartment, said wall having an unobstructed opening disposed about the axis of rotation of the barrel for freely permitting the discharge of the chlorine above the surface of the pulp in the pulp chamber.

CLASS 75—METALLURGY.

Subclass 185—Cyanides.

323222—July 28, 1885. J. W. SIMPSON. *Process of extracting gold, silver, and copper from their ores.*

The ore is crushed to a powder, treated with a solution produced by dissolving 1 pound of cyanide of potassium, 1 ounce of carbonate of ammonia, and one-half ounce of chloride of sodium in 16 quarts of water when the ore contains gold and copper only; but when it is rich in silver the quantity of chloride of sodium employed is increased. After thorough agitation of the ore in the solution the mixture is allowed to stand until the solution has become clear, when the dissolved metals are precipitated out by means of a plate of zinc suspended in the liquid. The metal is precipitated upon the zinc and can be removed by scraping or by dissolving the zinc in sulphuric or hydrochloric acid.

403202—May 14, 1889. J. S. MACARTHUR, R. W. and WM. FORREST. *Process of obtaining gold and silver from ores.*

The invention consists in subjecting finely-powdered argentiferous ores to the action of a solution containing a small quantity of a cyanide, the cyanide contents of the latter being proportioned to the quantity of gold or silver, or both, found, by assaying or otherwise, to be in the ore. Any cyanide soluble in water may be used, but in all cases the solution must be extremely dilute, since such a solution has a selective action in dissolving gold or silver in preference to the baser metals. The claim covers the use "of a cyanide solution containing cyanogen in the proportion not exceeding 8 parts of cyanogen to 1,000 parts of water."

418137—December 24, 1889. J. S. MACARTHUR, R. W. and WM. FORREST. *Process of separating gold and silver from ore.*

This invention has for its object the preventing of loss of cyanide in the case of weathered ores by first neutralizing the ore with an alkali or alkaline earth and then leaching such prepared charge with a cyanide solution. Further, the precious metal thus dissolved in the cyanide solution is precipitated out by passage through a sponge of zinc composed of fine threads or filaments of zinc formed by cutting shavings with a turning tool from a series of zinc disks held in a lathe, or by passing molten zinc at a temperature just above the melting point through a fine sieve and allowing it to fall into water.

482577—September 13, 1892. E. D. KENDALL. *Composition of matter for the extraction of gold and silver from ores.*

Consists in extracting gold and silver from minerals, "tailings," and other matters containing one or both of these metals by an aqueous solution of one or more soluble ferricyanides and one or more soluble cyanides prepared by dissolving a ferrocyanide in one portion of water and a cyanide in another portion and mixing the two solutions, or by adding either salt in solid form to the solution of the other.

492221—February 21, 1893. C. MOLDENHAUER. *Extracting gold from its ores.*

Consists in subjecting gold ores to the solvent action of cyanide of potassium in the presence of ferricyanide of potassium.

494054—March 21, 1893. W. A. G. BIRKIN. *Process of and solvent for separating precious metals from their ores.*

Covers the art of separating metals from their ores by subjecting the suitable comminuted ore to the action of a menstruum composed of potassium cyanide, potassium ferricyanide, and peroxide of hydrogen in water, and separating the values from this solution by precipitation, deposition, or electrolysis.

496950—May 9, 1893. H. PARKES and J. C. MONTGOMERIE. *Process of extracting gold or silver.*

Claims a process for extracting gold and silver from ores or compounds by an interrupted operation, consisting of treating the ore with cyanide of potassium in the presence of oxygen under pressure with agitation, the ore being subsequently filtered and washed and the precious metals recovered from the liquor by precipitation or other known means.

514157—February 6, 1894. W. P. MILLER. *Process of recovering precious metals.*

Has for its object the preservation of the cyanide solution, and consists in the treatment of the ore with the cyanide solution in air-tight vessels not only during the process of solution, but during the filtration and up to the time of the precipitation of the precious metals from the filtered solution.

522739—July 10, 1894. C. MOLDENHAUER. *Process of precipitating gold or other precious metals from their solutions.*

Dissolves gold and other precious metals from their ores by means of acid cyanide solutions, which consist in treating the solution with aluminum, so as to precipitate the gold from the solution, and then add a free alkali or alkaline earth for a regenerating solution.

524601—August 14, 1894. J. C. MONTGOMERIE. *Process of extracting gold or silver from ores.*

Sodium oxide (caustic soda) or other suitable oxide of the alkalies is added to the cyanide solution before mixing the same with the ore. After the precious metals have been dissolved in the solution and the liquid filtered off and the precious metals precipitated out, the remaining solution is tested to determine the quantities of potassium and sodium oxide still remaining in it, and any deficiency is supplied or the solution fortified by the addition of the necessary quantity of these agents, so as to restore the solvent solution to its original character and strength.

524690—August 14, 1894. E. D. KENDALL. *Method of treating gold or silver ores.*

Covers the treating of gold or silver ores with a composition of matter consisting of sodium dioxide and a suitable cyanide in solution.

532238—January 8, 1895. C. MOLDENHAUER. *Method of precipitating precious metals from solutions.*

Consists in subjecting the ores to the action of an acid cyanide solution so as to dissolve the gold or other precious metal contained in them, then adding aluminum so as to precipitate the gold or other metal from the solution, and then regenerating the cyanide solution by means of a free alkali or alkaline earth.

532895—January 22, 1895. J. C. MONTGOMERIE. *Process of extracting gold or silver from ores.*

Consists in adding an oxide or one of the alkaline bases to a cyanide solution, then mixing with the ore or compound the solution thus rendered alkaline, then conducting the process under pressure of oxygen, and afterwards separating from the ore the liquid containing the gold and silver in solution, then treating that liquid in any approved way for the recovery of the precious metal.

538951—May 7, 1895. S. C. CLARK. *Process of treating refractory ores.*

Claims the process of treating a refractory ore, consisting essentially in boiling the ore in water containing from 10 to 15 pounds of cyanide of potassium to each ton of ore for about one hour or for a sufficient length of time to enable the cyanide of potassium to dissolve the chloride, sulphide, or bromide in the ore, then allowing the solution to settle and finally evaporating the clear liquid so as to obtain a residue containing metal.

540359—June 4, 1895. G. KENNAN. *Process of and apparatus for treating ores.*

Claims the process of treating the ores of gold and silver, consisting in subjecting the same to the action of cyanide of potassium, agitating the same for a short period of time, discontinuing the agitation, and bringing air in contact therewith, the oxygen thereof increasing the action of the cyanide, continuing the agitation for a few minutes, until every particle of ore has been brought in contact with the cyanide solution in the presence of atmospheric air, and withdrawing the solution from the remaining pulp or ore.

541333—June 18, 1895. F. RINDER. *Process of separating gold and silver.*

Consists in the treatment of cyanide solutions containing gold and silver with sulphide of iron to precipitate the silver and then with chloride of zinc to precipitate the gold.

543543—July 30, 1895. M. E. WALDSTEIN. *Process of extracting gold or silver from ores.*

Consists in subjecting the ores to the action of cyanide of potassium, adding to the material during this action a salt or salts (such as binoxide of barium) decomposable by an acid and yielding oxygen, and sufficient acid to decompose this salt or salts, and subsequently adding an excessive acid to decompose the soluble cyanide and finally separating the precious metals as sulphides by precipitation with sulphureted hydrogen or by a soluble sulphide.

543672—July 30, 1895. M. CRAWFORD. *Process of extracting precious metals from their ores.*

Consists first in lixiviating the ores of the precious metals with a cyanide solution to which has been added a substantially neutral substance which contains a permanent excess of oxygen; second, in subjecting the gangue and accompanying cyanide solution to an amalgamating process; and, thirdly, in withdrawing the solution from the tailings, and extracting the precious metals therefrom. The neutral substance containing a permanent excess of oxygen may be prepared by mixing peroxide of sodium with dilute sulphuric acid and neutralizing with silicate of soda.

543676—July 30, 1895. M. CRAWFORD. *Process of extracting precious metals from their ores.*

Consists in, first, lixiviating the ore with a cyanide solution to which has been added a small quantity of a substance prepared by agitating ether with binoxide of barium and adding thereto small quantities of very dilute hydrochloric acid, and neutralizing by silicate of soda, and, second, separating the precious metal from this solution in which the ore has been lixiviated.

545852—September 3, 1895. P. DE WILDE. *Method of extracting gold.*

The precipitation of gold in the form of a mixture of aurous cyanide and cuprous cyanide by acidulating a cyanide solution containing the gold with an acid sulphurous compound and afterwards adding a solution of copper salt. Also, specifications provide for the dissolving of gold by the use of a weak solution of potassium or sodium cyanide which has been in contact with the minimum or protoxide of lead, and for the recovery and utilization of the spent cyanide by its conversion to Prussian blue.

547790—October 15, 1895. J. J. HOOD. *Extracting metals.*

The method for the extraction of precious metals from their ores, which consists in treating the ore with a solution containing both a cyanide of potassium or sodium and a salt or compound of a baser metal in the proportion of one part at least of the former to two parts of the latter; the metallic base of the solution being displaced by the precious metal, the former being precipitated. The gold is then precipitated out by a copper-zinc couple. By "baser metal" is meant mercury, lead, and such other metals as are displaced by metallic gold from their solutions in alkaline cyanides. A mixture that answers well consists of two parts, by weight, of cyanide of potassium (or its equivalent of cyanide of sodium), one part of mercuric chloride or its equivalent of sulphate or other mercury salt, and from one-half to two parts of caustic soda.

549736—November 12, 1895. J. C. MONTGOMERIE. *Extraction of gold and silver from ores.*

The improved process of extracting gold and silver from ores or compounds containing the same, consisting in treating the ore in a vessel containing water with a cyanide, an alkaline oxide, a nitrate, and an oxidizing agent. Sodium dioxide may be taken as a representative of the alkaline oxide and aid under pressure as an oxidizing agent, as set forth in this claim.

555463—February 25, 1896. J. S. MACARTHUR and C. J. ELLIS. *Process of extracting gold and silver from ores.*

Consists in subjecting the ore to the action of a cyanide solution and precipitating, by means of a metallic compound capable of combining with sulphur, any sulphur which may become soluble in the solution and thereby rendering it inert. Salts or compounds of lead, manganese, zinc, mercury, and iron are types of the metallic compound employed. By means of a salt of lead any copper present in the cyanide solution may be precipitated out.

555483—February 25, 1896. T. L. WISWALL and J. B. FRANK. *Process of recovering precious metals from solutions.*

The process of extracting precious metals from solutions by causing said solutions to flow through a precipitating alloy, subdivided into a mass of hardened filaments, and composed of zinc, lead, and one or more other metals which impart to said filaments a tensile strength sufficient to withstand the compression of the flowing solution, such as arsenic, antimony, cadmium, or bismuth, and in which alloy there is present not more than 97 per cent of zinc.

576173—February 2, 1897. H. L. SULMAN. *Process of precipitating precious metals from their solutions.*

Consists in purifying zinc fumes or dust of oxides by intimately mixing with the same an ammoniacal substance, and then mixing a quantity of said fumes or dust so purified with the solution. The apparatus by which to perform the process and for the treatment of the ores is also claimed.

578089—March 2, 1897. J. F. WEBB. *Process of extracting gold and silver from ores.*

The process or method for the extraction of gold and silver from their crushed ores, consisting in saturating the ores in a solvent solution of potassium cyanide, then applying a current of compressed air from beneath and maintaining the same throughout the leaching process, then shutting off the current, then applying a current of compressed air on top of the solution after the ore containing vat has been closed at top and a drain at the bottom has been opened, and maintaining the same until the solution has been driven out of the ore, then shutting off the current of air, then admitting water to the vat, then introducing a compressed air current at the bottom of the vat, and finally introducing a current of compressed air on top after the vat has been again closed at top and a drain opened at bottom.

578178—March 2, 1897. D. WHITE and T. M. SIMPSON. *Process of and apparatus for extracting precious metals from slimes, etc.*

In the extracting of precious metals from slimes and other auriferous and argentiferous materials, the process which consists in mixing the said material with a cyanide solution in a closed vessel, then agitating the mixture by passing a gas under pressure through the same, then passing gas under pressure, together with the gases arising from the action of the cyanide solution in the said material, through another quantity of said material and cyanide solution in a closed vessel, then conveying the gases back to the source of compression and drawing off the solution containing the precious metal and extracting said metal. The apparatus for accomplishing this purpose is also claimed.

578340—March 9, 1897. W. A. KONEMAN. *Process of extracting precious metals from their ores.*

The process of extracting precious metal from the ore containing it, which consists in wetting the ore, in a pulverized condition, with just sufficient cyanogen-containing solution to moisten the ore and reduce the mass to the condition of mud, maintaining the saturated ore in a quiescent state for a prolonged period of time, then diluting the mass and subjecting it to agitation for a suitable period of time, separating the resultant solution from the ore by filtration, and finally precipitating the precious metal from said solution.

578341—March 9, 1897. W. A. KONEMAN. *Process of recovering precious metals from cyanide solutions containing them.*

The process of recovering, by precipitation, the precious metal or metals contained in a cyanogen-containing solution, which consists in subjecting said solution to contact with an alloy composed of lead and zinc, and in which lead is the preponderating metal in weight, or with an alloy composed of lead, zinc, and aluminum.

580683—April 13, 1897. C. W. H. GÖPNER and H. L. DIEHL. *Recovery of gold and silver from their solutions.*

The process for the precipitation of gold and silver from their cyanide solutions, which consists in adding to said solutions a considerable quantity of cuprous cyanide, then adding an acid to effect precipitation, dissolving the latter by a fresh quantity of the cyanide solution obtained by leaching, and then adding acid to effect successive precipitations from said solution.

580948—April 20, 1897. J. C. MONTGOMERIE. *Process of treating cyanide solutions.*

The process for the extraction of the precious metals from cyanide solutions, which consists in filtering the solution through a charcoal filter, heating the filtering material on the same becoming surcharged with cyanogen or its compounds, condensing the resultant gases and obtaining ammonium cyanide and other ammonium salts in solution, applying the regenerated charcoal (still containing the precious metals) in the filtration of a further charge or charges of the solution, and ultimately recovering from the charcoal the precious metals accumulated therein.

587179—July 27, 1897. J. H. BURFEIND. *Treatment of gold and silver ores.*

As an improvement in the extracting of precious metals from their ores, the treatment of the cyanide product or precipitate containing said metals, preparatory to melting the said product with sulphurous acid.

591753—October 12, 1897. E. J. FRASER. *Process of obtaining precious metals by solution.*

The process of treating gold and silver ores by solution, which consists in converting the metal bases of dioxides of the alkaline metals into sulphates, by the addition of sulphuric acid, so as to produce hydrogen dioxide, preventing the decomposition of the hydrogen dioxide by an excess of acid, separating the solution from the metallic sulphate, mixing the solution with a solution of cyanide of potassium and lime in the presence of a precious metal, and leaching the liquid holding the precious metal.

592153—October 19, 1897. J. S. MACARTHUR. *Precipitating precious metals from solutions.*

The process of precipitating a precious metal from a cyanide solution, which consists in subjecting said solution containing a base metal to the action of a precipitant protected by a metal inert in said solution. Such a precipitant is found in zinc, mercury, or copper protected by lead. When copper is present in the cyanide solution, this copper is removed by the precipitant prior to the removal of the precious metal.

601201—March 22, 1898. S. NEWHOUSE, A. J. BETTLES, and T. WEIR. *Method or process of extracting precious metals from their ores.*

A method or process for the extraction of the precious metals from their ores, said method or process consisting, first, in neutralizing the acidity of the ore where this condition exists; second, in placing the ore in a suitable solution of cyanide of potassium and subjecting the mass to agitation; third, in adding a quantity of zinc to the mixture of ore and cyanide and subjecting the mass to further agitation; and fourth, in adding quicksilver or mercury charged with sodium amalgam, and finally agitating the entire mass for purposes of amalgamation.

607719—July 19, 1898. M. E. WALDSTEIN. *Process of recovering precious metals from their solutions.*

The process for extracting and recovering precious metals from their ores, which consists essentially of the following steps: First, subjecting the ore in a powdered state to the action of an aqueous solution of a cyanide; second, supplying to the solution charged with the precious metals that quantity of zinc dust determined to be exactly sufficient to precipitate said metals; third, agitating said solution and said zinc dust until said metals are precipitated and said zinc dust is absorbed; fourth, recovering the precious metals from the valuable precipitate of the preceding step by filtration, or other process.

610616—September 13, 1898. H. L. Sulman and F. L. Teed. *Extraction of precious metals from their ores.*

The essence of this invention consists in the employment of haloid compounds of cyanogen in combination with free cyanide of potassium or other suitable cyanide of the alkalies or alkaline earths as a solvent for precious metals in their ores, examples of such haloid compounds of cyanogen being found in cyanogen chloride, or bromide or iodide.

620100—February 28, 1899. W. A. Caldecott. *Method of extracting gold from cyanide.*

An improved method for the precipitation of gold from gold bearing cyanide solutions by passing such solutions over zinc shavings previously treated with a soluble salt of mercury, such as perchloride of mercury ($HgCl_2$).

624040—May 2, 1899. C. B. Jacobs. *Process of reducing metals from their solutions.*

The process of reducing metals from their solutions, consisting in subjecting them to the action of gaseous phosphide of hydrogen in the presence of an alkaline material, thereby precipitating the noble metals in a metallic state and the base metals as phosphides, and then separating the latter from the noble metals.

625564—May 23, 1899. E. D. Kendall. *Process of treating gold or silver ores and composition of matter for same purpose.*

A composition of matter to be used for extracting precious metals from ores, tailings, or other bodies, consisting of a suitable thiocyanate and a suitable ferrocyanide in watery solution.

625565—May 23, 1899. E. D. Kendall. *Process of treating gold or silver ores and composition of matter for same purpose.*

A composition of matter to be used for the extraction of precious metals from ores, tailings, or other bodies, consisting of a suitable thiocyanate and hydrogen dioxide in watery solution.

629905—August 1, 1899. J. J. Hood. *Process of extracting gold or silver.*

The process of extracting gold, silver, and mercury from solutions by bringing the solutions into contact with an alloy of zinc, antimony, and mercury, from time to time distilling off mercury from the alloy, and finally recovering the gold and silver from it. The precipitant used consists of an alloy of about one hundred parts of zinc, five parts of antimony, and twenty parts of mercury.

630982—August 15, 1899. W. Kemmis-Betty and B. Searle. *Process of recovering gold from pulp, slimes, or similar substances.*

The process of extracting gold from ores, which consists of the following steps: First, dissolving the gold in the pulp in a weak solution of cyanide of potassium; second, adding a stronger solution of cyanide of potassium to the gold-bearing solution in the proportions specified; third, immediately after so strengthening the solution, passing the same through a body of zinc shavings coated with lead.

635199—October 17, 1899. J. Smith. *Process of treating gold or silver ores.*

The process for treating gold and silver ores, tailings, slimes, and like materials containing precious metals, which consists in mixing the material to be treated with caustic lime, saturating or covering the mixture entirely with water and keeping it thus until all the acid present has combined with the lime, drying the material, exposing it to the action of atmospheric air, and treating it with a cyanide.

636114—October 31, 1899. J. S. Cain, A. Soderling, and S. M. MacKnight. *Preliminary treatment of ores or tailings before cyaniding.*

The method or process of treating ores containing the precious metals, which consists in first leaching said ores or tailings in a weak solution of nitric acid, or of nitric and sulphuric acids, subsequently leaching the same in an alkaline solution, and finally leaching the same in a cyanide solution.

636288—November 7, 1899. H. de Raasloff. *Process of extracting precious metals from ores.*

The improvement in the process of separating precious metals from their ores, consisting in mixing with the ore a solution consisting of a base and a solvent for precious metals, which solvent is capable of being separated from the said base by oxygen, and adding liquid air to the ore and solution, or by evaporating the nitrogen from liquid air, and adding the oxygen which remains to the mixed ore and solution.

638372—December 5, 1899. M. B. Zerener. *Precipitation of precious metals from their cyanide solutions.*

The process of precipitating gold and silver from cyanide solutions by causing the solution to move in one direction, and during such movement passing through it, in the opposite direction and in the form of a spray, or a number of fine streams or films, mercury charged with alkali metal.

641818—January 23, 1900. C. Whitehead. *Process of extracting gold from ores.*

The process of extracting gold from ores in which the particles of free gold are enveloped in a compound of a base metal having the following characteristics, to wit; nonsiliceous, oxidized, practically impervious to a solvent solution, such as one of cyanide, not readily removable by washing with water, and insoluble in water, but soluble in dilute acids, consisting in first subjecting the crushed ore to the action of heat sufficient to convert the coating into a porous condition and afterwards treating the ore with a cyanide solution.

642767—February 6, 1900. G. Thurnauer. *Process of separating precious metals from their mixtures with zinc.*

The process of treating the mixture of zinc and precious metals resulting from the treatment of cyanide solutions of the precious metals by zinc, which consists in subjecting said mixture to the action of a solution containing lead and then to the action of acid, whereby the zinc is dissolved and the precious metals remain in admixture with metallic lead.

646006—March 27, 1900. J. C. Montgomerie and H. Parkes. *Treatment of gold and silver ores, etc.*

In the extraction of gold and silver from ores or compounds containing the same, the process consisting in treating the ore or compound with a cyanide of an alkali metal, caustic alkali, and barium dioxide, in conjunction with ammonium sulphate.

646808—April 3, 1900. T. Cruse. *Method of extracting gold and silver from their ores.*

The process of recovering precious metals from their ores, which consists in first heating the ore pulp to the boiling point, adding cyanide of potassium to the hot mass, permitting the mass to gradually cool, and while it is cooling adding to the mass the following: Bluestone, iron sulphate, sulphuric acid, and quicksilver.

649628—May 15, 1900. W. A. Caldecott. *Extraction of gold or other precious metals from slimes.*

The method of extracting precious metals from finely divided materials, such as slimes, containing reducing substances, such as ferrous sulphide or hydrate, which consists in rendering the material alkaline, then forcing air into the pulp until the ferrous compounds are converted into ferric hydrate, then adding cyanide and continuing aeration and agitation until the precious metals are dissolved.

651509—June 12, 1900. F. W. Martino and F. Stubbs. *Precipitation of precious metals from cyanide solutions.*

A process for the precipitation of the precious metals from their aqueous cyanide solutions, consisting in passing acetylene and atmospheric air through such solutions, or by adding calcium carbide to them, and precipitating the metals in a metallic state.

651510—June 12, 1900. F. W. Martino and F. Stubbs. *Treatment of ores and precipitation of precious metals from their cyanide solutions.*

A process for the precipitation of precious metals from their aqueous cyanide solutions, consisting in treating such solutions with a hydrocarbon gas, produced when a metallic carbide is decomposed by water, and capable of precipitating the metals in a metallic state. Aluminum carbide is given as an example of such a metallic carbide. The use of methane as a precipitant is also claimed.

657181—September 4, 1900. H. de Raasloff. *Process of separating precious metals from their ores.*

The continuous process of treating ores of precious metals, consisting in mixing the finely divided ore with a suitable solvent for the precious metals, inducing the mixture to flow continuously from and back to the point of admixture, while so flowing introducing liquid oxygen or liquefied air into the mixture, then causing the mixture to flow with sudden variations of velocity to agitate it, then separating the solution from the base earthy mineral matter, and sending it continuously through an electro-depositing bath, where the precious metal is deposited, and thus in continuous ordered succession.

656395—August 21, 1900. E. H. Dickie. *Process of leaching ores or tailings.*

The improvement in the process of leaching ores or tailings with a solution which dissolves the precious metals, which consists in adding to the solution an agent composed of an acetate of an alkali metal or of alkali earth metals which is capable of readily uniting with and forming acetates of the base metals, and which has little or no affinity for the precious metals, thereby enabling the solvent to act directly upon the latter, and then leaching the ores. Calcium acetate is cited as an example of an acetate of an alkali-earth metal.

664060—December 18, 1900. J. P. Schuch, Jr. *Process of extracting precious metals from their ores.*

A method of extracting precious metals from their ores, which consists in combining the crushed ore with a cyanide solution while both are in a warm condition, mechanically mixing the ore and solution by agitation simultaneously with the commingling thereof, charging the mixture during the agitation with hot air, and finally separating the ore and slush or pulp from the metal in solution.

665105—January 1, 1901. J. C. Kessler. *Process of extracting gold and silver from ores.*

The process of separating precious metals from auriferous and argentiferous ores, consisting, first, in subjecting the ores to the action of an aqueous solution, consisting of cyanide of alkali metal, yellow prussiate of potassium and permanganate of an alkali metal in substantially the proportions of water, one thousand (1,000) parts; yellow prussiate of potassium, two and one-half (2.5) parts; cyanide of alkali, two and one-half (2.5) parts; permanganate of potassium, one-tenth (0.1) part, until the gold and silver contained in such ores are dissolved; second, separating the metals from their solution by the application of a soluble lead salt, by which the cyanide solution is decomposed and a nonsoluble cyanide of lead is formed, at the same time a nonsoluble cyanide of gold or silver is precipitated; third, by the application, to the sediment thus precipitated, of sodium amalgam, whereby a gold, silver, and lead amalgam is produced and at the same time a concentrated solution of cyanide and ferrocyanide of sodium is regenerated; and fourth, diluting the concentrated cyanide solution with a quantity of water and regenerating and reenergizing the aqueous solution for reüse by the addition of permanganate of alkali.

671704—April 9, 1901. E. D. Kendall. *Process of treating ores containing silver or silver and gold.*

The process of treating ores or other bodies for the extraction of precious metals, which consists in treating them with a suitable chemical solution containing a thiocyanate and a cyanide, capable of dissolving silver or silver and gold, and in then treating the so-dissolved silver by a suitable sulphide, such as potassium sulphide, and in so regulating the amount of the sulphide to the silver as that they shall substantially equalize each other in separating the sulphur sulphide and in returning the thiocyanate and cyanide into subsequent operations for further treatment of the ore.

673425—May 7, 1901. G. A. Duncan and F. H. Beach. *Method of treating precious metal bearing ores.*

The method of treatment of precious metal bearing ores to cause the precious metal to be dissolved from the ore, and the resulting metal bearing liquor and impoverished ore to be separated from each other, which consists in the following steps: First, maintaining a substantially continuous supply stream of mingled comminuted ore and solvent liquor; second, mechanically dispersing such mingled ore and liquor into the air, in a direction transverse to the onward movement of the stream, without separating the ore from the liquor; third, delivering the resultant stream of mingled metal bearing liquor and impoverished ore and receiving the same in mingled condition and carrying it onward; fourth, sucking the liquor from the tailings; fifth, delivering water to the impoverished tailings remaining, and subsequently sucking such wash water therefrom; sixth, delivering such impoverished ore or tailings after the application of such suction.

682612—September 17, 1901. E. L. Godbe. *Method of leaching ores.*

The method of leaching ores, which consists in disposing moistened ore in superimposed strata within a containing receptacle by a continuous mechanical agitation in the lower portion of the latter to form a lower thoroughly agitated stratum of heavier portions of the ore, a stratum of lighter portions or particles next above which are agitated to a less degree, a stratum of slimes and other lighter particles next above which remain substantially immobile, and a top covering of a clear supernatant solution, introducing the ore below the upper surface of said latter solution, overflowing and carrying off the clear solution, replacing water in the charge by a cyanide of potassium solution introduced at the bottom of the receptacle below the lower heavier stratum and causing it to percolate upwardly through the strata above, increasing the agitation during the introduction of said cyanide solution, carrying off the metal bearing cyanide solution which overflows from the top of the charge and precipitating the said overflow metal bearing solution after it leaves the receptacle.

689190—December 17, 1901. B. Hunt. *Process of precipitating and recovering precious metals from their solutions.*

The process of precipitating precious metals, consisting of adding to the pulp a cyanide solution and agitating the same until the metal is extracted; then adding to the pulp, while continuing the agitation thereof, powdered metallic aluminum whereby the precious metal is precipitated, but in suspension in the pulp; then adding mercury and continuing the agitation until the metal is in the form of an amalgam, and finally recovering the precious metal by treating the amalgam.

692634—February 4, 1902. H. Davis. *Process of extracting precious metals from their ores.*

A process for the extraction of the precious and other metals from ore, ore pulp, sands, slimes, tailings, mineral bearing earths or other substances containing these metals, which consists in introducing chlorin gas into the ore and afterwards wholly or partially removing the excess of chlorin by forcing air into the material and afterwards treating with a cyanide solution to dissolve the chlorides.

694521—March 4, 1902. B. W. Begeer. *Cyanide process of extracting precious metals from ores.*

The process of treating material containing the precious metals, consisting in setting in motion in an endless path a solution of cyanide of potassium, introducing oxygen to the moving liquid, and finally subjecting the metal bearing material to the action of said solution.

696274—March 25, 1902. E. Schilz. *Cyanide process of extracting precious metals from their ores.*

An improved process in the art of extracting precious metals from their ores, said process consisting in thoroughly and intimately mixing peroxide of barium (BaO_2) with precious metal bearing material, and then subjecting the same to treatment with an alkaline cyanide solution.

701002—May 27, 1902. J. B. de Alzugaray. *Method of extracting precious metals from their ores.*

The process for treating ores containing precious metals and consisting in adding the crushed ore to a solution of sodium chloride, sodium carbonate, and potassium cyanide, then forcing through the mass a gaseous mixture of bromine and air and recovering the precious metals from the solution by any known means, such as electrolysis.

702305—June 10, 1902. E. D. Kendall. *Process of extracting precious metals from their ores.*

The process of treating ores carrying precious metals, which consists in treating such ore with a lixiviating solution, consisting of a cyanide, potassium percarbonate, and water, and finally extracting the precious metal from such lixivium.

705698—July 29, 1902. R. H. Officer, J. W. Neil, J. H. Burfeind, and F. H. Officer. *Cyanide process of working gold, silver, or other ores.*

The improvement in treating ores by the cyanide process, consisting in agitating the pulp containing the cyanide solution by a suitable gas under pressure, passing the gas and the hydrocyanic-acid gas liberated from the solution through a regenerating solution, and using the gas after passing through said regenerating solution to agitate a fresh quantity of pulp.

706303—August 5, 1902. L. B. Darling. *Process of extracting precious metals from ores.*

The process of extracting precious metals from finely divided materials or ores, which consists in spreading a comparatively thin layer of the material over a substantially flat and large working surface provided with drainage ducts or channels; then covering said material with suitable metal dissolving or cyanide solution; then passing a heavy roll back and forth over the charge of material, etc., thereby at the same time thoroughly agitating or stirring the charge and forcing some of the solution into the drainage ducts; then discharging said solution into the sump, and finally precipitating the precious metal from the solution.

707926—August 26, 1902. W. Hilt and C. E. Lane. *Process of extracting precious metals.*

The process of extracting precious metals from solutions thereof, which consists in producing cyanide solutions of said metals, vaporizing metallic zinc by means of heat, and conducting the vapor thus formed to a point beneath the surfaces of said solutions, thus producing finely divided zinc, which replaces the precious metals and thereby causes their precipitation.

708504—September 2, 1902. H. L. Sulman and H. F. Kirkpatrick-Picard. *Treatment of ore slimes.*

The process of treating ore slimes, which consists in separating, by means of a centrifugal machine, the ore slimes from the residual water with which they are mixed by adding a little lime to the charge, removing the bulk of the water, thereafter introducing into the machine an amount of leaching solution of a volume equal to that of the remaining quantity of adhering moisture and introduced into the slimes by centrifugal action, and replacing the moisture by the added leaching solution.

710496—October 7, 1902. S. T. Muffly. *Process of treating ores.*

The process of treating ores, which consists in injecting into said ores, as they are agitated and elevated and allowed to fall by gravity in a closed chamber, a chemical solution in the form of a spray, together with hot air under pressure, and allowing the elements and fumes freed by this operation to escape from said chamber.

718633—January 20, 1903. T. B. Joseph. *Gold extracting process.*

The process of extracting gold or silver from ore containing the same, when in a suitable condition, which consists in subjecting the said ore to the leaching action of a solution of water, cyanide of potassium, hydrate of calcium, and carbonic-acid gas, and introducing an oxidizing agent into the solution, and subsequently precipitating the gold from this solution.

719274—January 27, 1903. Z. B. Stuart. *Process of extracting metals from ores.*

The process of extracting precious metals from ore, consisting in agitating the pulp together with cyanide, water, and air by ebullition in one vessel, causing the mixture to assume an even consistency throughout, and passing the mixture through a mechanical agitator and combining therein a relatively smaller quantity of mixture with a relatively larger quantity of air and there forcing the pulp, cyanide, water, and air into intimate contact, and circulating the mixture through the two vessels.

722455—March 10, 1903. August Prister. *Process of precipitating gold from cyanide solutions.*

The process for the precipitation of gold or other precious metals from cyanide solutions, such as potassium cyanide, sodium cyanide, and bromine cyanide, which consists in acidifying the solution, adding a solution containing salts of mercury and copper, and then adding a solution containing zinc salts and a small percentage of a potassium ferrocyanide, or a small quantity of the cyanide solution discharged from the ordinary zinc-precipitation boxes.

722762—March 17, 1903. J. P. Schuch, Jr. *Process of separating precious metals from solvent solutions.*

The process of separating precious metals from their solvent solutions, which consists, first, in passing the solution through crushed limestone or phonolite to neutralize any free acid, then through zinc, wood ashes, asbestos wool or its equivalent, and charcoal or coke, to neutralize any free soda or carbonates, then through zinc shavings to precipitate the precious metals, then through charcoal to filter the solution and effect retention of a percentage of the precious metals, then through limestone or crushed phonolite to effect precipitation of zinc contained in the solution, and then alternately through zinc, charcoal, or coke and zinc to effect complete separation of the precious metals and thorough filtration of the solution.

725895—April 21, 1903. M. V. Uslar and G. Erlwein. *Process of extracting gold.*

The process for extracting gold from auriferous ores, which consists in lixiviating the ores with a solution of potassium cyanide, rhodanides, hyposulphites, and sodium chloride.

726294—April 28, 1903. F. J. Hoyt. *Method of extracting gold from ores.*

The method of milling gold ore, consisting of the following steps: First, pulverizing the ore; second, distributing the ore thinly over a wide, long, and open sluiceway; third, flowing the ore and propelling it forward over its bed by the action of a stream of chemical solution adapted to dissolve the ore; fourth, automatically screening and separating the solution from the tailings by the same force; and fifth, subjecting the solution to a reagent to precipitate the gold therein.

727659—May 12, 1903. F. W. Martino. *Method of extracting noble metals.*

The process of recovering gold from its cyanide solution, consisting in acidifying the solution and treating it at a raised temperature with barium-sulpho-carbide. The latter is manufactured by fusing two parts, by weight, of barium sulphate (baryta or heavy spar) $BaSO_4$ in an electric furnace with one part of carbon.

728397—May 19, 1903. T. B. Joseph. *Gold extracting process.*

The process of extracting gold and silver from ore containing the same when in a suitable condition, which consists in subjecting the said ore to the leaching action of a solution of water, cyanide of potassium, hydrate of calcium, peroxide of barium and carbonic acid gas, the ore being agitated by compressed air.

730835—June 9, 1903. D. Mosher. *Ammonia cyanide process of treating copper, nickel, or zinc ores containing precious metals.*

The process of treating refractory sulphur, tellurium, and arsenical ores containing copper, zinc, nickel, gold, and silver, consisting in first roasting such ores at a low red heat to transform the metals so transformable into sulphates, arsenates, or tellurates; then oxidizing reducing compounds by very dilute ammonia; and subsequently extracting the metals with an ammoniacal cyanide solution containing an excess of cupric oxide or hydroxide over and above that necessary to form metallic cyanide double salts.

731169—June 16, 1903. O. A. Ellis. *Apparatus for extracting metals from ores.*

An apparatus for extracting metals from ores, having in combination a receiving hopper having an inclined bottom, a discharge opening in said hopper, and inclined chute leading from said hopper and provided with a screen, a precipitating box connected with said inclined chute, means for causing a flow of chemical solution through said hopper, chute, and precipitating box and means for passing a current of electricity through said precipitating box.

731631—June 23, 1903. J. T. Terry, Jr. *Extracting gold or silver from slimes.*

An improvement in separating precious metals from slimes with which they are mixed, consisting in forming a solution with water, spraying said solution into tanks containing a cyanide solution made dense by the addition of salt, allowing the slime to settle through and into the solution, then drawing the clear liquor from the top through vertically disposed filters and discharging the sludge from the bottom into succeeding tanks containing a similar cyanide solution, allowing it to settle and again drawing off the clear liquor.

731839—June 23, 1903. G. A. Bahn. *Sulphuric acid process of extracting precious metals from solutions.*

The process of precipitating precious metals from solutions thereof, which consists in producing cyanide solutions of said precious metals, then acidulating with sulphuric acid said cyanide solutions, then immersing zinc in sheet, plate, or other form in the acidulated cyanide solution containing the precious metals; the chemical action thereupon taking place in the solution, dissolving zinc and precipitating the precious metals; then recovering from the precipitate of the preceding operation the precious metals by filtering and melting, or other process.

732605—June 30, 1903. G. E. Thede. *Process of leaching ores.*

The process of leaching ores which consists in mixing with the ore to be treated a cyanide solution, peroxide of hydrogen, and an oxide which is reducible by said peroxide of hydrogen.

732639—June 30, 1903. T. B. Joseph. *Gold extracting process.*

The process of extracting gold and silver from ore containing the same, when in a suitable condition, which consists in subjecting said ore to the leaching action of a solution containing water, cyanide of potassium, bromine, hydrate of calcium, peroxide of barium, and carbon dioxide, said carbon dioxide being forced into the leaching solution simultaneously with compressed air.

738758—September 15, 1903. J. B. de Alzugaray. *Extraction of precious metals from their ores.*

The process for extracting precious metals from their ores, consisting in first moistening the crushed ore with an alkaline solution and afterwards agitating it in a solvent solution and blowing through it an oxidizing agent composed of gaseous bromine and its acid and oxyacid compounds dissolved in air and finally recovering the metals from the solvent in any well-known manner.

745490—December 1, 1903. T. J. Grier. *Process of extracting precious metals.*

The process of extracting precious metals from slimes, consisting in directing the slimes into a settling tank, drawing off the thicker portions of the slimes and depositing the same into a leaching vat, of introducing a cyanide solution under pressure through perforations in the false bottom of the vat, causing the watery portions of the slimes to be displaced by said cyanide solution, then treating the charge with an air under pressure, and afterwards introducing through the false bottom of the vat a salt solution of greater density than the cyanide solution to displace the latter.

745828—December 1, 1903. E. B. Hack. *Process of extracting metals from ores.*

A cyanide process, consisting of the following steps in the order named: caking the pulp by pressure under conditions allowing the moisture to escape; introducing a weak solution of the solvent simultaneously with the introduction of air under pressure; drying the pulp by passing air under pressure therethrough; introducing a stronger solution of the solvent simultaneously with the introduction of air under pressure; and finally drying the cake by air pressure.

755951—March 29, 1904. J. Smith. *Process of treating ores.*

In the cyanide treatment of ores, the method of rendering insoluble in the cyanide solution ferrous oxide contained in a mass of moist crushed ore, which method consists in applying heat to said mass in the presence of air, previous to its treatment by the cyanide solution.

CLASS 204—ELECTROLYSIS.

Subclass 15—Aqueous Bath, Ores.

61860—February 5, 1867. J. H. Rae. *Improved mode of treating auriferous and argentiferous ores.*

This invention consists in treating auriferous and argentiferous ores with a current of electricity or galvanism for the purpose of separating the precious metals from the gangue. In connection with the electric current suitable liquids or chemical preparations, such, for instance, as cyanide of potassium, are used, in such a manner that by the combined action of the electricity and of the chemicals, the metal contained in the ore is first reduced to a state of solution and afterwards collected and deposited in a pure state.

Among the claims is one for the use of the platinum agitator as an electrode.

62776—March 12, 1867. J. H. Rae. *Improved mode of collecting gold and silver from sweepings, washings, etc.*

This invention consists in treating sweepings, filings, and washings containing gold or silver with a current of electricity or galvanism for the purpose of separating the precious metals from the impurities of foreign matter mixed with them. In connection with the electric current suitable liquids or chemical preparations, such, for instance, as cyanide of potassium, are used in such a manner that by the combined action of the electricity and chemicals the precious metals contained in the sweepings, filings, and washings are first reduced to a state of solution, and afterwards collected and deposited either as oxides or in a metallic state, and the operation of extracting or separating said precious metals from the sweepings, filings, or washings is attended with very little trouble and expense. During this operation the bath which contains the washings, filings, or sweepings acts as an electrode, and also as an agitator; and the third claim of the patent covers the use of this carbon electrode as an agitator.

90565—May 25, 1869. W. J. Lynd. *Improved process of separating iron and other metals from potters' clay.*

The process of removing iron, copper, and other discoloring matters from potters' clay and other argillaceous substances by subjecting the clay, when in solution, to the action of one or more magnets, or by passing through the bath containing such solution a current of electricity.

239300—March 22, 1881. A. Ryder. *Apparatus for treating ores.*

The invention has reference to apparatus for reducing ores in which the ore, while in a heated state, is dumped suddenly into a liquid or chemical solution for the purpose of disintegrating the ore and separating the particles preparatory to amalgamation. And the inventor claims, in an apparatus for disintegrating ores preparatory to amalgamation, the insulated vessel or nonconductor of electricity, provided with a metallic or plated hopper, in combination with an electrical generator or battery and conducting wire or wires.

246201—August 23, 1881. E. Reynier. *Electro-chemical treatment of ores.*

The method of treating ores of zinc and lead for the production of electricity and recovery of the metals by acting upon said ores in a voltaic couple with an electrolytic liquid having caustic alkali as the base, and precipitating the metallic oxides from said liquid.

272391—February 13, 1883. A. Thiollier. *Process of and apparatus for extracting metals from their ores.*

In combination with an electro-generator, a receptacle for conductively prepared ore or other material containing metal to be recovered, having attachments for the negative and positive polar conductors of the electro-generator, arranged, as described, in electrical communication with the mass of conductive ore by means of the electrolytic solution, whereby reduction is effected when the current is passed.

286208—October 9, 1883. L. Létrange. *Process of and apparatus for reducing zinc ores.*

The process of reducing zinc ores and producing pure metallic zinc and sulphuric acid simultaneously therefrom, which consists in simultaneously roasting sulphuret ores and carbonate ores in the same or communicating chambers, and thereby converting both ores into soluble sulphates, then leaching these roasted ores, and then depositing the metallic zinc from a solution of the sulphates by electric currents on metallic plates, and drawing sulphuric acid at the same time from the solution as fast as set free by the said electric currents; and the apparatus for use in the process of reducing zinc ores, which consists, essentially, in a reservoir for the sulphate solution; a precipitating vessel provided with suitable anodes and cathodes; a pipe provided with a regulating cock, leading from the reservoir to near the bottom of the precipitating vessel, and an outlet pipe for the freed acid, arranged in the said vessel at the desired level of the liquid therein, whereby the strength and quantity of the sulphate solution in the precipitating vessel are maintained constant.

291670—January 8, 1884. M. Body. *Process of and apparatus for obtaining gold and silver from their ores by combined electrolytic and amalgamating processes.*

The method of first subjecting gold and silver ores to the action of ferric salts, in combination with the electrolytic process, and the subsequent amalgamation of the metals with mercury under the continued action of the electric current; and the apparatus for effecting this process.

300950—June 24, 1884. H. R. Cassel. *Process of and apparatus for the separation of metals from ores and alloys.*

The process of separating metals from ores or alloys, especially those of an auriferous character, which consists in charging the ore or alloy in a powdered condition into an anode compartment, which is separated from the cathode compartment by porous material, said anode compartment containing a solution yielding nascent chlorine under the action of an electric current, and agitating said powdered material within said solution during the passage of the electric current; and the combination in an apparatus for treating ores and metals by electrolysis, of a cathode compartment, a negative pole therein, a rotary drum constituting the anode compartment, provided with porous material separating it from the cathode compartment, and with a series of carbon rods or plates arranged within the same, and suitable electric connections.

300951—June 24, 1884. H. R. Cassel. *Process of chloridizing ores by electrolysis.*

In the process of extracting gold from rebellious or refractory gold ores, the steps which consist in subjecting the ore to the action of a solution yielding nascent chlorine under electrolytic decomposition, and adding lime or its equivalent, whereby acids formed by secondary action during said decomposition are neutralized.

317245—May 5, 1885. E. P. Thompson. *Apparatus for the separation of gold from its ores by electro-chlorination and deposition.*

The combination, with an electrolytic cell for separating chlorine from its compounds and its anode, of a battery, a cathode consisting of a pipe through which steam is admitted to the cell for the purpose of increasing the rapidity of the separating, and conductors respectively connecting the same anode and cathode with the poles of said battery.

317246—May 5, 1885. E. P. Thompson. *Apparatus for the electro-deposition of gold from its chlorides.*

The combination, in an electrolytic cell, of an anode formed of a series of carbon rods set in a metal ring, and a cathode formed by two thin corrugated copper plates connected electrically, which are set, respectively, within and without the circle of carbons.

332705—December 22, 1885. H. H. Eames. *Apparatus for chloridizing gold, silver, and other ores.*

This invention consists of an iron vessel cylindrical in shape, lined with wood, having a cast iron cover, adjusted so as to be steam and vapor tight. It is also arranged with a set of stirrers, to which motion is communicated by crown and pinion wheels. It is also fitted with pipes, by means of which steam can be forced through the contents and held there under pressure. It is also furnished with two electrodes, by which electricity can be passed through the ore and chemicals operated upon, while the pressure is applied. The electric current is best obtained from a dynamo machine of ordinary construction used in the deposition of metals.

333815—January 5, 1886. M. Body. *Process of obtaining gold, silver, copper, nickel, and cobalt from their ores by electrolytic action.*

The process of separating gold, silver, copper, and other metals from chlorinated or chlorine containing ores by electrolytic action, consisting in first roasting the ores or subjecting them to an equivalent oxidizing treatment, as specified, and then subjecting the ore to the action of ferric-salt solutions, and at the same time passing an electric current through said solution, whereby the metal becomes dissolved and precipitated, and chlorine gas is generated at the positive pole, which reconverts the resulting ferrous salts into ferric salts.

351576—October 26, 1886. H. R. Cassel. *Process of extracting gold, etc., from ores.*

The process of separating metals from ores or alloys, especially those of an auriferous character, which consists in charging the ore or alloy in a powdered condition into an anode compartment, which is separated from the cathode compartment by a porous partition composed of asbestos, which permits the passage of the current with the metals in solution, and retains the ores within the anode compartment, said anode compartment containing a chloride solution, agitating and subjecting the charge to nascent chlorine produced from said solution during the passage of the electric current, passing the solution of metals through the asbestos partition, and depositing the metals in solution at the cathode.

357659—February 15, 1887. D. G. Fitzgerald. *Obtaining chlorine by electrolysis.*

The electro-chemical generation of chlorine by means of an anode of peroxide of lead in the form of dense, highly conductive layers, plates, or masses of any required form preferably obtained by the means hereinbefore described, the said anode being employed in conjunction with any suitable cathode and with an electrolyte capable of evolving chlorine.

360852—April 12, 1887. H. R. Cassel. *Apparatus for separating metals from ores or alloys.*

In an apparatus for separating metals from ores or alloys by electrolysis the combination of a journaled drum provided with carbon anodes, a hollow metallic shaft insulated on its exterior and extending through said drum, said shaft being perforated within the drum and separated from the interior thereof by a filter, and a screw conveyor within said hollow shaft.

360853—April 12, 1887. H. R. Cassel. *Apparatus for separating metals from ores or alloys.*

In an apparatus for separating metals from ores or alloys by electrolysis the combination of a rotary drum constituting the anode compartment and having a suitable electric connection, a rotary cathode compartment having a suitable electric connection and provided with an automatic valve, a porous diaphragm separating said anode and cathode compartments, a fixed bracket, and an arch shaped arm attached to said bracket in the path of said valve for opening of the latter.

362022—April 26, 1887. H. Liepmann. *Apparatus for separating metals from ores or alloys by electrolysis.*

In an apparatus for separating metals from ores or alloys by electrolysis the combination of an anode compartment, a cathode compartment, a filtering diaphragm separating said compartments, a dense porous diaphragm for separating said compartments during one step of the operation, and mechanism whereby the dense porous diaphragm may be placed in apposition with or removed from the opening between the anode and cathode compartments.

379764—March 20, 1888. C. F. Croselmire. *Wet process of extracting pure zinc from its ores.*

The process which consists in immersing roasted zinc ore in dilute acid, passing an air blast through the solution until the impurities are oxidized, and finally drawing off the zinc solution and depositing or precipitating the zinc.

387036—July 31, 1888. C. P. Bellows. *Process of cleansing gold and silver where mechanically coated in ores with refractory substances.*

The process of cleansing refractory ores prior to the recovery of the precious metals therefrom, which consists in immersing said ores in a solution of a sodium chloride and caustic soda, heating said solution, and at the same time subjecting the ores to the action of the electric current, whereby the ore is rendered free milling.

391360—October 16, 1888. H. H. Eames. *Apparatus for chloridizing ores.*

In a device for chloridizing metallic ores, the combination of a hermetically sealed tank, metallic plates placed inside the said tank and mounted upon insulated supports, whereby they will be insulated from each other and from the tank, the said plates forming the two elements of a galvanic battery, a stirrer placed in the said tank and between the said plates a solution containing the ore to be treated, by which a galvanic current will be excited between the said charging steam in the said tank, whereby the said solution will be heated and a pressure maintained in said tank.

399209—March 5, 1889. J. H. Rae. *Electric amalgamator.*

In an apparatus for working ores, a pan or tub with an internal copper ring and rotating arms or stirrers, in combination with a horizontal wooden ring suspended above the tub, a copper plate forming the upper surface of said ring and perforated to admit carbons which pass loosely through the plates, said carbons having heads or transverse pins at the upper ends, and the movable elastic plates or springs pressing upon the heads of the carbons to hold them in contact with the copper plate.

407386—July 23, 1889. J. C. Wiswell. *Bath or solution for separating metals from their ores.*

The process of producing a bath or solution for the separation of metals from their ores, consisting in subjecting a solution of salt water, muriate of ammonia, and muriatic acid to a current of electricity, then placing this solution in a tank containing liquid mercury, and subjecting the whole to a current of electricity, said mercury serving as the anode.

410228—September 3, 1889. J. C. Wiswell. *Solution for use in separating metals from their ores.*

A solution or bath for use in separating metals from their ores, consisting of chlorine in solution, sodium chloride, ammonium chloride, hydrochloric acid, and bichloride of mercury.

415576—November 19, 1889. W. von Siemens. *Process of electrodeposition of metals.*

The process which consists in lixiviating ore in separate vessels with a solution containing ferric sulphate, passing the resulting ferrous sulphate successively through a series of compartments containing cathode plates, and in which cells the solution is subjected to the action of an electrical current by which the metal in solution is deposited, then passing the remaining liquid successively through a second series of compartments containing anode plates of insoluble material and separated from the first-mentioned compartments by nonmetallic diaphragms, whereby the ferrous sulphate is oxidized and reconverted into ferric sulphate, which solution is again used to lixiviate ores.

418134—December 24, 1889. H. F. Julian. *Process of extracting gold and silver from their ores.*

The improvement in the process of extracting gold and silver from ores, which consists in agitating the pulverized ore in closed vats with chlorine, bromine, or iodine and water under pressure of a fluid forced into the vat, and after the gold and silver have combined with the halogen, adding mercury and again agitating under pressure of a fluid forced into the vat, next passing the ore, mercury, and solution over amalgamated copper surfaces forming the cathode of an electric circuit, and subsequently submitting the mixture to electrolytic action between cathodes of mercury below and suitable anodes above.

452125—May 12, 1891. W. von Siemens. *Apparatus for extracting metals from their ores.*

The combination of a trough for the flow of liquid, composed of numerous sections connected at alternate ends, with an inlet at one end and an outlet at the other, with two longitudinal shafts in each section of the said trough, said shaft carrying beaters and being entirely immersed in the liquid contained in the trough, and a heating pipe located below and between the said shafts.

459023—September 8, 1891. C. Schreiber and H. Knutsen. *Process of extracting antimony from ores.*

In the extraction of antimony from ore, the process which consists in subjecting the crushed ore to the action of a solution of sulphide of sodium and then precipitating the antimony in metallic form by electrolysis, adding hydroxide of sodium to the solution.

460354—September 29, 1891. W. von Siemens. *Apparatus for electrolytically separating metals from ores.*

In an electrolytical cell, the combination of a revolving cathode, a trough shaped anode situated below the said cathode, in the trough of which the cathode revolves, a screen permitting the passage of the electrolyte and of electricity and capable of preventing the passage of vibrations of the electrolyte situated between the said cathode and anode, and means for supplying the electrolyte above the screen and for withdrawing the oxidized liquid from the bottom of the trough of the anode.

473105—April 19, 1892. G. J. Atkins. *Electrolytic apparatus for separating gold and other metals from their ores.*

Electrolytic apparatus for separating gold and other metals from their ores, which consists of an upright anode compartment through which the ore is passed continuously, having within it an anode constructed to receive and retard the descent of the ore, while the ore itself forms a more or less soluble portion of such anode pole, and an upright cathode compartment and pole, the said anode and cathode compartments communicating through an opening closed by a porous diaphragm and having outlets at their lower ends for the removal of the ore which has been acted upon in the anode compartment and of the metals and other substances that have been deposited or precipitated in the cathode compartment.

484869—October 25, 1892. G. J. Atkins. *Process of separating gold and other metals from their ores.*

The continuous process of separating gold and other metals from their ores, which consists in passing such ore through the anode compartment of an electrolytic apparatus in contact with the anode and retarding the descent of the ore in the said anode compartment while such ore is kept in contact with the anode pole of such compartment, so as to form a more or less soluble portion of such anode pole, and then subjecting the ore to the process of amalgamation.

495212—April 11, 1893. J. F. Wiswell. *Process of, and apparatus for, treating ores.*

An improved process of treating ores which consists in submerging mercury in a solution of common salt connecting the mercury with the positive pole of a generator and the salt solution with the other pole, so that the current will decompose the salt solution and cause the chlorine to be attracted to the mercury forming calomel; treating the calomel with aqua regia forming a soluble mercuric chloride, diluting the latter with water, treating undecomposed salt solution with an electric current to produce sodium hypochlorite and introducing the soluble mercuric chloride and sodium hypochlorite simultaneously upon the crushed ore.

495637—April 18, 1893. J. Pfleger. *Process of extracting zinc by electrolysis.*

The process of obtaining zinc by electrolysis out of a zinc containing anode, which consists in adding to the bath a basic zinc-salt solution adapted to act as electrolyte, to which basic zinc-salt solution a conducting neutral salt has been added.

495715—April 18, 1893. S. R. Whitall. *Process of lixiviating ores.*

The process of separating gold and silver from their ores, which consists, first, in roasting the ore to oxidize the base metals; and, secondly, in subjecting the roasted ore to the action of a solution of potassium cyanide and sodium hyposulphite, and subsequently precipitating the dissolved metals; and the process of separating gold and silver from siliceous ores, which consists in subjecting the ore admixed with caustic soda and potash to the action of a solution of potassium cyanide and sodium hyposulphite.

497014—May 9, 1893. F. W. Cleghorn. *Process of separating precious metals from ores.*

The process of separating gold and silver from ores, consisting in filtering through the ores a solution of sulphuric acid and salt, and precipitating the gold and silver in the filtrate solution by placing metallic iron in the filtrate and passing an electric current through the filtrate.

501997—July 25, 1893. S. H. Emmens. *Apparatus for the electrolytic extraction of metals.*

In apparatus for the electrolytic extraction of metals, a vat having an anode lining on its floor and sides, in combination with a suitable cathode or cathodes suspended within the vat and a nonporous and nonconducting inner wall or curb located between the side linings and the cathode or cathodes and extending from the upper surface of the floor lining to above the surface of the electrolyte, and serving to support a lining of the substance to be acted upon in contact with the anode side linings and to prevent short-circuiting between said anode side linings and the cathodes.

507130—October 24, 1893. C. Hoepfner. *Electrolytic production of metals.*

The process of obtaining copper and silver free from other metals, which consists in forming a cuprous chloride solution of these metals by leaching a cupriferous and argentiferous material with a cupric chloride solution containing a solvent for cuprous chloride, separating from the cuprous chloride solution so obtained such metals as arsenic, antimony, cobalt, and the like, extracting the silver by precipitation, electrolyzing the cuprous chloride solution, preventing the solution at the anode from commingling with the solution at the cathode, mixing together the two solutions after having been acted upon by the electric current and preventing an accumulation of iron therein by oxidizing and removing the latter.

512361—January 9, 1894. P. C. Choate. *Art of producing metallic zinc.*

The method of producing from an impure solution of zinc salts a zinc electrolyte free from depositable impurities, which consists in subjecting the solution to the action of an electric current to precipitate and deposit the depositable impurities, and at the same time preventing the re-solution of such impurities in the solution by neutralizing the acid set free in the bath with a neutralizing agent which is free from any depositable impurities soluble in the solvent element of the bath.

512362—January 9, 1894. P. C. Choate. *Process of preparing solutions carrying salts of zinc.*

The process of forming a solution carrying salts of zinc, which consists in forming a sulphate solution of the soluble elements of the ore and recovering the same therefrom by evaporation and crystallization, heating the crystallized product to drive off the salts of metals more volatile than zinc and convert those less volatile than zinc into compounds insoluble in water and finally treating the mass with water to dissolve the zinc element.

518732—April 24, 1894. P. C. Choate. *Art of producing metallic zinc.*

The process of continuously producing metallic zinc by electrolysis, which consists in depositing the zinc from an acidulated solution of a zinc salt, drawing off from the bath the free acid liberated therein, dissolving in such acid oxidized zinc, in the state of fume, freed from its more volatile soluble impurities, and returning the solution thus formed to the bath from time to time, as required, to maintain the electrolyte.

526099—September 18, 1894. P. DANCKWARDT. *Apparatus for and process of extracting gold or silver from ores.*

The process of extracting gold and silver from ores, which consists in subjecting the same simultaneously to the action of cyanide of potassium, an alkali sulphide, and to electrolysis; and the combination of a main apparatus consisting of a revolving outer drum having blades, an insulated inner drum and electric connections, with an auxiliary apparatus consisting of a series of communicating tanks, rotating insulated drums and electric connections.

528023—October 23, 1894. L. PELATAN and F. CLERICI. *Extracting gold from its ore.*

The combination with a crushing mechanism and an amalgamator, of a series of vessels containing a solution of cyanide of potassium and a salt of sodium, each vessel having an amalgamated copper bottom connected to one pole of a generator of electricity and a central shaft having a zinc pipe and agitator connected to the other pole, a filter, a series of communicating closed vessels of lead, each containing a body of aluminum chips resting on a perforated diaphragm above the inlet and rising nearly to the outlet, and means for creating a vacuum beneath the filter to drive the fluid through and into the series of lead vessels under pressure.

531169—December 18, 1894. V. ENGELHARDT. *Process of extracting metals from sulphide ores, etc.*

The process of treating the sulphur compounds of metals, which compounds have combined therewith other ore compounds not soluble in a solution of an alkaline sulph-hydrate, which consists in extracting the sulphur compounds by treatment with an alkaline sulph-hydrate, thereby also generating sulphureted hydrogen, subjecting the solution thus formed to the action of an electric current in the cathode compartment of an electrolytic cell, in the anode compartment of which is an alkaline chloride, thereby obtaining the metals, reforming the sulph-hydrate, and liberating free chlorine, treating the ore residues, resulting from the sulph-hydrate bath with such chlorine, and subjecting the solution thus obtained to the action of the sulphureted hydrogen first generated in the sulph-hydrate bath.

537423—April 9, 1895. F. H. LONG and D. C. SKADEN. *Apparatus for recovering precious metals from their ores.*

An apparatus for recovering precious metals comprising a revoluble drum, a perforated metal tube opening from said drum and provided with a fabric jacket, a series of plates secured to the inner surface of the drum and having inwardly extending blades or flanges electric connections to the plates and tube for rendering the same of opposite polarity, a rotatable conveyor located and working in said tube and a fixed vent pipe passing axially through the drum head and opening into the interior of the drum near the top thereof.

538522—April 30, 1895. E. D. KENDALL. *Process of and reagent for recovering silver and gold from solutions.*

The process of the recovery of gold and silver from solutions, which consists of the following steps: (first) the subjecting of the ore containing the precious metals to the action of a solvent, thus obtaining an aqueous solution of the solvent and the minerals contained in the ore; (second) subjecting the said solution to the electro-chemical action of a mercurial amalgam; (third) subjecting the valuable precipitate secured by the preceding process to the action of dilute acid in the presence of carbon; (fourth) the recovery of the valuable metal from the result of the preceding process.

543546—July 30, 1895. E. J. FRASER. *Process of and apparatus for treatment of precious metals.*

The process of separating gold or other precious metal held in an electrolytic solution, which consists in passing the solution through a vessel containing alternating porous layers of zinc and carbon, to set up a local voltaic action which tends to decompose the solution, precipitating the gold in the carbon by filtration.

543673—July 30, 1895. M. CRAWFORD. *Process of extracting precious metals from their ores.*

The improved process of removing precious metals from their ores which consists, first, in lixiviating the ore with a cyanide solution which has been subjected to the action of an anode separated from its corresponding cathode by a porous partition which substantially prevents the circulation of the electrolyte; second, in withdrawing said solution and removing the precious metals therefrom; third, in again subjecting the solution to the action of an anode separated from its corresponding cathode as before and using it over again in continuous rotation.

543674—July 30, 1895. M. CRAWFORD. *Process of extracting precious metals from their ores.*

The improved process of extracting precious metals from their ores, which consists in forming a solution of a cyanide and a cyanate of the corresponding base, the total amount of cyanate being not less than 25 per cent of the total amount of cyanide present; lixiviating the ore therewith and extracting the dissolved precious metals from said solution.

543675—July 30, 1895. M. CRAWFORD. *Apparatus for extracting precious metals from their ores.*

An apparatus for extracting precious metals from their ores, which consists in the combination of a tank wherein the solvent liquid is stored; a revoluble lixiviating receptacle; a pipe running from said storage tank to the lixiviating receptacle; an amalgamating table; means for causing the lixiviating receptacle to discharge its contents continuously upon the amalgamating table; a separating tank; means for conducting ore which has passed over the amalgamating table into the separating tank; means for separating the solid contents of this separating tank from its liquid contents; a third tank; connections whereby the solvent liquid thus separated is passed to said third tank; means for reclaiming the precious metals from the solution in said third tank; and connections whereby the solvent liquid is run from the third tank to the storage tank; and a separator for removing the tailings of the ores of precious metals from their accompanying solvent solution, which consists in the combination of a tank into which the ores and solution are discharged; a conveyer running from the bottom of said tank to a point exterior thereto by which the solids are separated from the liquids; a car filter with a permeable bottom situated below the discharge end of the conveyor; and a second tank below said car filter.

544610—August 13, 1895. E. W. CLARK. *Process of and apparatus for extracting ores by electrolysis.*

In an electric chlorinator for gold ores, the combination of the hollow cylinder constructed in longitudinal sections united by bands, and having the series of separate boxes or chambers communicating with its interior; the electrical connections consisting of the anode in the cylinder chamber, and the cathodes in the boxes or amalgamating chambers, the agitator shaft provided with the spirally arranged series of stirrer arms and adapted to revolve in the cylinder chamber, and the stuffing boxes at the ends of the cylinder.

546873—September 24, 1895. E. A. ASHCROFT. *Process of treating zinc-bearing ores.*

In the treatment of zinc bearing ores and zinc bearing products, the method of simultaneously depositing zinc from a catholyte free from iron, and raising a ferrous salt solution to the ferric state, which consists in passing the zinc bearing solution free from iron, around the metallic cathodes of an electrolytic apparatus, and simultaneously passing the ferrous salt solution around the insoluble anodes of the said electrolytic apparatus.

549907—November 19, 1895. A. L. ELTONHEAD. *Apparatus for extracting gold.*

In an apparatus for extracting gold and other metals, the combination of a mercury receiving box, a horizontally movable vessel therein, having its lower end open and unobstructed whereby mercury placed within the box may, in seeking its level, enter said vessel, a horizontally placed anode strip suspended within the latter, means for adjusting the strip vertically, a cathode connection and conductor wires adapted to connect the anode and cathode with a suitable dynamo or battery.

551648—December 17, 1895. L. PELATAN and F. CLERICI. *Electrolytic process of obtaining precious metals.*

In an apparatus for the extraction of precious metals by direct electrolytic action, the combination with an electrolytic vat having cathodes arranged at its bottom, of anode cylinders arranged above the said cathodes, anode plates alternating with said cylinders, a generator of electricity having its poles connected to said anode cylinders and plates and to the cathodes, means for rotating the anode cylinders which are provided with agitators, a force pump having injection pipes to discharge beneath the anode plates and cylinders, said pipes being provided at or near their mouths with interior, concentric rods having spiral ribs, or feathers, and suction pipes having their open ends arranged above the anode plates.

552960—January 14, 1896. C. HOEPFNER. *Process of producing cuprous oxides.*

The process which consists in leaching cupriferous materials with a cupric chloride solution containing calcium chloride, whereby a solution containing cuprous chloride is obtained, converting the cuprous chloride in a portion of the solution into cupric chloride by means of a suitable acid as sulphurous acid in the presence of oxygen, freeing the other portion of the solution from metals other than copper, and converting the cuprous chloride therein into cuprous oxide by means of a suitable reagent, as caustic lime.

553816—January 28, 1896. L. PELATAN and F. CLERICI. *Process of and apparatus for extracting gold from its ores.*

A single continuous process for the extraction of precious metals from their ores, and the amalgamation of the same, which consists in treating said ores with a comparatively weak solution of a soluble cyanide, such as cyanide of potassium, adding thereto a peroxide such as hydrogen binoxide, increasing the electric conductivity of said solution by adding chloride of sodium, increasing the solvent power of said solution by passing a relatively weak current of electricity through the same, retaining the sodium chloride in the solution practically without decomposition and continuously revolving the anode in the solution over a fixed cathode of mercury.

556092—March 10, 1896. O. FRÖLICH. *Process of extracting noble metals from ores.*

The process of extracting precious metals from a lye containing also inferior metals, said lye containing substantially five grains of each of the said metals to the pint, which consists in subjecting the said lye to the action of an electric current of substantially twelve amperes for each two square yards of cathode surface, whereby the gold is separated by electrolysis.

563143—June 30, 1896. J. DOUGLAS. *Process of extracting copper from ores.*

The method of extracting copper from solid cuprous chloride, which consists in moistening said solid cuprous chloride with water, inserting both electrodes of an electric circuit in the said solid cuprous chloride, and then passing an electric current therethrough.

563144—June 30, 1896. J. DOUGLAS. *Process of extracting copper from ores.*

The process of extracting copper from the solid cuprous chloride, which consists in suspending the said solid cuprous chloride in an acidulated electrolyte, inserting the cathode of an electric circuit into the solid cuprous chloride, and the anode into the electrolyte, and passing an electric current therethrough.

566894—September 1, 1896. P. DANCKWARDT. *Apparatus for extracting gold and silver from ore.*

The combination of a revolving barrel having an amalgamated copper lining with nonconducting bottoms, a series of inclined perforated metal strips secured to such bottoms, insulating rings that sustain the bodies of such strips, and with electric connections that communicate with the barrel and the strips.

566986—September 1, 1896. R. KECK. *Cyanide process of extracting precious metals from their ores.*

The process of extracting precious metals from their ores, which consists in dissolving said metals in a cyanide solution and extracting them therefrom by electrolytic precipitation effected by alternating plates of lead and aluminum, the former being anodes and the latter cathodes.

567503—September 8, 1896. L. PELATAN and F. CLERICI. *Process of extracting gold and silver from their ores.*

The process, which consists in submitting the ores of gold and silver to the action of a comparatively weak cyanide solution containing chloride of sodium, intensifying the solvent power of the solution by the passage of a continuous electric current having an electro-motive force below that required for the decomposition of sodium chloride, and continuously revolving the anode from which the current is supplied to the solution over a mercury cathode.

568090—September 22, 1896. L. PELATAN and F. CLERICI. *Electrolytic apparatus for extracting gold and silver from their ores.*

The combination with a vat having a flat bottom, of a cathode of mercury spread thereon, an anode having the form of an endless belt, rolls arranged near the ends of the vat to support and give continuous movement to said anode in parallelism with the surface of the cathode, and means for imparting continuous movement to said anode, in one direction, it being provided with stirring devices moving with it.

568724—October 6, 1896. E. ANDREOLI. *Apparatus for electro-deposition of gold or silver.*

In an apparatus for the electro-deposition of gold and silver from a solution, a tank provided with one or more anodes and a series of amalgamated cathodes, each cathode consisting of perforated, skeleton, or network plates and a layer of mercury in the bottom of the tank into which each of the cathodes dips, said layer of mercury being connected with the negative pole of electricity, thereby constituting a common vehicle for the current from all the cathodes while at the same time maintaining the said cathodes constantly amalgamated.

568741—October 6, 1896. H. R. CASSEL. *Process of extracting gold from substances containing it.*

The process of extracting gold from ores, which consists in decomposing a bromide of an alkaline base by electrolysis, dissolving the gold by the anode solution, adding the cathode solution, running the product through a mixture of iron and carbon to precipitate the gold, and redecomposing the liberated bromine solution by electrolysis.

568843—October 6, 1896. V. ENGELHARDT and A. NETTEL. *Process of treating metallic sulphides.*

The process of treating a metallic sulphur compound, which consists in first converting the said compound into a soluble double sulphide by treating it with any suitable reagent, such as the sulph-hydrate of calcium in aqueous solution; then decomposing the resulting solution by electrolysis to produce the metal and sulphureted-hydrogen gas, then treating the spent solution with carbonic acid gas to precipitate a carbonate of the base and liberate sulphureted-hydrogen gas, then recovering the oxide of the reagent and the carbonic-acid gas from the precipitate by calcination, then combining the sulphureted-hydrogen gas given off during the process with the said oxide to form more reagent, and using the recovered carbonic-acid gas to treat more spent solution.

571468—November 17, 1896. T. P. Barbour. *Process of treating ores.*

The process of treating ores, which consists in first treating the raw material with copper oxide and sulphuric acid, then chlorinating the pulp thus treated, introducing the chlorinated mass into a suitable agitator having zinc therein, and establishing an electric current through the mass in the presence of zinc; and a chlorinating tank for treating ores consisting of a revoluble cask having a single manhole and a circular series of bungholes, copper pole disks secured within the cask at opposite ends thereof and arranged in an electric circuit, insulator bracing posts arranged between said disks and the outer heads of the tank, flanged guide rings encircling said cask at an intermediate point, spurrings encircling the cask near its opposite ends, and a horizontal drive shaft carrying guide rolls engaging said flanged guide rings and drive pinions engaging said spur rings.

573233—December 15, 1896. M. Netto. *Process of precipitating precious metals from their alkali cyanide solutions.*

The process of precipitating silver and gold from their alkali cyanide solutions, which consists in acidulating the alkali cyanide solution containing said metals with hydrochloric acid so as to precipitate silver chloride, separating said silver chloride by filtration, subjecting the acid filtrate to the action of the electric current so as to deposit the gold on the cathode, and regenerating the cyanide solution by the addition of caustic alkali.

578171—March 2, 1897. C. P. Turner. *Electrolytical apparatus.*

An electrolytic apparatus, provided with an anode consisting of a nonconducting receptacle coated with an anticorrosive substance and provided with an outer coating of a conducting material and means for connecting said outer coating with the positive pole of a source of electrical supply.

579872—March 30, 1897. J. H. Haycraft. *Process of treating auriferous and argentiferous ores.*

The process of treating ores consisting in introducing the ore into a pan, adding thereto mercury and soluble salts capable of yielding chlorine by electrolysis, raising the ore contents of the pan to about the boiling point of water and passing a current of electricity through the heated mass while stirring the same to secure a simultaneous electrolytic chlorination and electro-amalgamation, and maintaining the anode out of vertical alignment with the mercury cathode.

581160—April 20, 1897. H. Hirsching. *Process of treating ores containing silver and gold.*

The process of treating ores, which consists in subjecting them in the presence of moisture to the action of ammonia and a nitrate, and then precipitating the metal or metals from the resulting solution.

582077—May 4, 1897. E. Motz. *Apparatus for extracting precious metals.*

In an apparatus for extracting precious metals, the combination of a rotative drum provided with a manhole and having a valved connection for the admission of compressed air, a core of insulating material mounted to turn in the said drum, metal plates forming the positive and negative electrodes of an electric circuit and arranged respectively on the drum and core, and an electrical connection for said plates on the core, the said connection being arranged to lock the drum and core together.

584242—June 8, 1897. P. G. Salom. *Process of making commercial lead from lead ore.*

The process of converting lead ore into commercial lead, without the application of heat, by subjecting the ore to the action of nascent hydrogen, electrolytically developed, producing thereby a spongy mass, and afterward, while the mass is in a nonoxidized condition, applying a consolidating pressure.

585355—June 29, 1897. C. A. Burghardt and G. Rigg. *Process of obtaining metallic zinc and copper from ores.*

The improved process of recovering metallic zinc and metallic copper from cuprous zinc ore, which consists in treating the roasted and ground ores with an ammoniacal solution, then in freeing the resultant liquid from iron dissolved by said solution, then in depositing the metallic copper on suitable metallic plates acting as a couple, and in finally effecting the electrolytic deposition of the metallic zinc.

585492—June 29, 1897. J. F. Webb. *Method of an apparatus for separating precious metals from their solvent solutions.*

The improved method of separating precious metals from a solventsolution containing the same, consisting in passing the solution alternately through a body of carbon and zinc, and subjecting the same in its passage to an air current; and a metallurgical filter for this purpose containing the same, consisting of a series of alternate compartments, or receptacles, containing, respectively, carbon and zinc, through which the solvent solution is passed with an upward and downward flow, and electric circuit completing connection between the zinc and carbon.

588076—August 10, 1897. B. Mohr. *Process of treating sulphide ore.*

The process for treating sulphide ore by acting on the pulverized ore with acid sodium or potassium sulphate, so as to obtain a solution of sulphate of zinc, depositing the zinc by electrolysis and thus recovering the acid alkali sulphate, and treating the insoluble residue obtained by the lixiviation for recovery of the other metals.

588740—August 24, 1897. B. Becker. *Apparatus for treating gold and silver ores.*

In apparatus for the treatment of gold and silver ores the combination of a vat provided with amalgamating plates and adapted to contain cyanide of potassium, in solution, and the ore to be treated, a vat containing the electrodes of an electrolytic apparatus and means for causing the circulation of the cyanide of potassium solution through the amalgamating vat, and for distributing it in the electrolytic vat.

590801—September 28, 1897. W. L. Brown. *Process of treating rebellious ores.*

The process of treating ores finely divided and mixed with water, which consists in adding a suitable compound to said ores and water, which compound contains an element which has a chemical affinity for the base constituents of the ore, then passing an electric current through said material to unite the said element chemically with the base constituents and to liberate the precious metals, then circulating the material over an amalgamated surface which is not in the electrical circuit, and finally returning the material again through the field of electrolytic action.

592055—October 19, 1897. E. C. Ketchum. *Process of treating ores.*

The process of treating mixed sulphide ores containing lead and zinc, which consists in first roasting the ores, then subjecting the roasted ores to the action of a solution of caustic alkali in the presence of heat to remove from the ores the lead and the zinc, then subjecting the caustic solution containing the lead and zinc to electrolytic action in one or more cells to remove the lead, the anodes of which cells are immersed in a volume of pure caustic solution, which is separated by a porous medium from the electrolyte containing the lead and zinc, and then subjecting the caustic solution or electrolyte containing the zinc only to electrolytic action in one or more cells to remove the zinc.

592973—November 2, 1897. E. Motz. *Electrolytic apparatus.*

In an electrolytic apparatus the combination with a frame or sluice of a series of convex cathode plates located in the bottom of said frame or sluice, a series of anode plates having curved under faces and disposed above said cathode plates, blocks secured to the anode plates and supported in the frame or sluice, each block having a recess in its upper edge, a series of conductors connected with said anode plates and terminating in said recesses in the blocks, a conducting rod disposed in said recesses on the first-mentioned conductors and having a notch therein, a crossbar passing through said notch, a conductor with which said crossbar is electrically connected, locking devices for securing the crossbar to the frame or sluice, and a conductor connected with the cathode plates.

594611—November 30, 1897. S. H. EMMENS. *Process of and apparatus for removing zinc from zinciferous ores.*

The process of treating zinciferous ores, which consists in pulverizing and roasting the ore, leaching it in a series of vessels through which the solution flows continuously, and subjecting the contents of each vessel intermittently to electrolytic action, whereby the solution is rendered alternately acid and neutral or more acid and less acid in contact with each body of ore; and an apparatus for treating zinciferous ores, comprising a series of leaching vats, each provided with an inlet pipe extending to the bottom and with an exit pipe or trough leading from the top of the vat, and each provided at bottom with an insoluble anode, a series of movable cathodes suspended above said vats, means for raising and lowering the cathodes of adjoining vats alternately, and an electric circuit to the respective poles with which said anodes and cathodes are connected.

597820—January 25, 1898. N. S. KEITH. *Art of obtaining gold and silver from auriferous and argentiferous materials.*

The process of obtaining a precious metal from its ores, which consists first in dissolving the gold or silver in a cyanide solution containing cyanide of mercury and free cyanide of an alkaline metal, such as cyanide of potassium, and then passing a current of electricity through said solution to a metallic cathode, whereby an easily removable layer of the precious metal and mercury is simultaneously deposited upon said cathode.

598193—February 1, 1898. E. ANDREOLI. *Apparatus for electro-deposition of gold and silver.*

In apparatus for the electro-deposition of gold, silver, or other metals, anodes of peroxidized lead acting in the presence of and in combination with a cyanide or cyanide-compound solution.

600351—March 8, 1898. E. A. ASHCROFT. *Treatment of metalliferous ores and products.*

The improved process of preparing a solution suitable for leaching zinc bearing ores of zinc bearing products, consisting in electrolyzing a zinc bearing solution successively in contact with a suitable cathode and an anode resulting from the preliminary furnace treatment of products or ores containing copper and iron, and then depositing the copper from the resulting ferrous solution, and simultaneously raising the iron content of such solution to the ferric state by electrolyzing the said resulting ferrous solution successively in contact with suitable cathodes and insoluble anodes.

601068—March 22, 1898. F. W. WHITRIDGE. *Method of and apparatus for extracting gold from its ores.*

The method of extracting gold from a weak cyanide solution, which consists in circulating the solution over anodes of iron and cathodes of lead, said cathodes being formed of thin plates arranged at short distances apart and having from 9 to 10 square meters of surface for each ton of solution in contact with them; and subjecting the said solution while in motion to an electric current of from 3.5 to 4 volts, and of from 0.5 to 1.5 amperes per square meter of cathode surface; and in apparatus for obtaining gold from a weak cyanide solution by electrolysis, the combination with a cell provided with anodes of iron and cathodes of lead formed of thin plates, said cathode plates having from 9 to 10 square meters of surface to each ton of solution in the cell; of means for circulating the solution in the cell, and means for subjecting the solution to a weak current of electricity.

603904—May 10, 1898. J. R. HEBAUS. *Apparatus for extracting precious metals.*

An apparatus for extracting precious metals from their ores, comprising a tank having an amalgamated copper lining forming a cathode and a multiplicity of agitators, each rotating on its own axis and at the same time traveling around the tank, the said agitators forming an anode and an electric circuit.

605835—June 21, 1898. E. and G. ANDREOLI. *Electrolytic production of amalgams, etc.*

An apparatus for the production of amalgam, consisting of a cell provided with positive and negative compartments separated by porous diaphragms, the negative compartments having a raised middle portion in the form of a table or block between the sides of which and the said partitions are narrow vertical spaces, the top of the block or table and the vertical spaces being covered and filled with a continuous body of mercury forming a cathode.

614572—November 22, 1898. J. C. MCNULTY. *Method of and apparatus for treating ores.*

The art of extracting precious metals from their ores, consisting in mixing pulverized ore with an electrolytic fluid, causing the mixture to flow from one level to another between adjacent electrode plates of opposite polarity, passing an electric current between said plates and vibrating the electrodes in a direction substantially at right angles to the plane of said electrodes for the purpose of preventing the polarization thereof; and in apparatus for the electrolytic treatment of ores the combination of a plurality of vats arranged in pairs communicating at the top, adjacent electrode plates of opposite polarity suspended within said vats and connected with a source of electricity, vibratory supports for said electrodes, means for vibrating the same at substantially right angles to their planes, a pressure conduit for pulp leading to the bottom of the first vat to provide an upward current therethrough, and an exit at the bottom of the succeeding vat providing a discharge for the downward current of pulp overflowing from the top of the vat preceding.

616891—January 3, 1899. G. D. BURTON. *Electrolytic apparatus for treating metals and ores.*

In an electrolytic ore treating apparatus, the combination of a tank for containing an electrolyte, an anode disposed in said tank, a cathode disposed in said tank, a screen or deflector also disposed in said tank between the anode and cathode and adapted to distribute the ore or material being treated, said screen having a conductive surface connected to the negative pole of an electric source whereby it is adapted to collect a portion of the product reduced from the ore by the action of the current and the electrolyte.

617911—January 17, 1899. E. A. SMITH and M. H. LYNG. *Method of extracting metallic ores.*

The wet process of extracting copper from its ores having precious metal therein, which consists in digesting the pulverized ore under action of heat and an oxidizing agent, in presence of sulphuric acid, exposing the dissolved sulphates to metallic copper for precipitation of the silver, treating the filtrate electrolytically to deposit the copper, evaporating the lean electrolyte to concentrate the free acid, and crystallize the metallic sulphates, and finally calcining such crystallized sulphates to properly regenerate them as oxidizing agents for reuse.

623822—April 25, 1899. L. PELATAN. *Apparatus for treating ores or the like.*

In apparatus, the combination with a circular vat, of a revolving anode, situated above and parallel to a mercury cathode, with an unobstructed space above the surface of the cathode, the said anode having arms which extend close to the peripheral wall of the vat and are suspended from a shaft, and are provided with pins or stirrers projecting upward and downward to within a short distance of the underlying cathode, and projections or baffles extending inwardly from the inner surface of the peripheral wall of the vat.

626972—June 13, 1899. T. CRANEY. *Electrolytic apparatus for deposition of metals from solution.*

In an electrolytic apparatus, the combination of an outer tank provided with suitable feed and discharge connections for the liquid into the bottom and top, respectively, and an electrolytic couple, composed of sheet or analogous electrodes each folded in a fabric, with oppositely projecting marginal portions and rolled together into a tight bundle and sealed in the tank, whereby the fabric inclosing the electrode forms a porous medium through which the electrode is compelled to flow.

627442—June 20, 1899. L. PELATAN. *Process of electrolytically treating ores.*

The improvement in processes of treating ores electrolytically, consisting in adding to a sludge, consisting of ore and water, a solvent and picric acid as an oxidizing agent and then passing an electric current therethrough.

631040—August 15, 1899. J. E. GREENAWALT. *Process of extracting precious metals from their ores.*

A process for the treatment of gold and silver ores which consists, first, in properly roasting the pulverized ore; second, placing the ore in a filtering vat; third, washing the ore to remove soluble salts; fourth, in passing through the ore an electrolyzed solution consisting of a solution of chlorides—chiefly sodium and ferric chlorides—with a small percentage of bromides and small quantities of chlorine, bromine, and hypochlorous acid, with such other compounds as result from the electrolysis of a chloride and bromide solution; fifth, passing the solution after it leaves the ore through a precipitating tank; sixth, passing the solution after it leaves the precipitating tank through the positive or anode compartment of an electrolytic cell, keeping the solution separate and distinct from the solution in the negative or cathode compartment of the cell; and, seventh, returning the solution from the regenerating cell to the ore in the vat and passing it thence to the precipitating tank, again to the regenerating cell, and again to the ore as often as may be required to effect the necessary saving of the values.

633544—September 19, 1899. H. S. BADGER. *Electrolytic apparatus for precipitating metals.*

A precipitating tank comprising the tank body, having a mercury coated surface in its bottom, a revoluble shaft suspended in the tank and provided with hollow arms having perforations on their lower sides to deliver air or vapor in proximity to the said surface, means for rotating the revoluble devices, means for introducing air or vapor to the hollow arms, and an electric circuit in which the shaft, agitating arms, and mercury coated surface are located.

639766—December 26, 1899. L. E. PORTER. *Apparatus for extracting precious metals from ores.*

The combination of a rotatable barrel adapted to form the cathode; a porous lining of nonconducting material arranged inside the barrel; a lining of filtering material arranged inside the nonconducting lining; anode plates arranged inside the filter lining; a source of electrical energy, having one pole connected with the barrel and the other pole connected with the anode plates.

640718—January 2, 1900. C. P. TATRO and G. DELIUS. *Process of extracting precious metals.*

In the process of separating precious metals from ores, the steps comprising electrolytically depositing a portion of the precious metals in the bath upon a drum cathode revolving partially immersed in the bath, at the same time scraping the said deposit from the drum, also simultaneously depositing other portions of similar precious metals in the same bath upon a cathode of sodium amalgam.

641571—January 16, 1900. W. WITTER. *Process of producing solution of cyanogen halide.*

The process for producing a solution of cyanogen halide by electrolyzing in a bath without a diaphragm and with inert electrodes a solution containing an alkali cyanide, an alkali halide, and the salt of a metal which forms an insoluble hydroxide.

649151—May 8, 1900. W. WRIGHT. *Apparatus for extracting metals from refractory ores.*

An apparatus for extracting metals from refractory ores, comprising a tank for receiving a sludge of such ores; a stationary, horizontal, perforated partition in said tank, forming beneath it a chamber; a cathode on the bottom of the tank within said chamber; a filtering medium carried on the partition; a number of pins arranged in a series of concentric circles projecting upward from said partition; a main driving shaft; a series of radial arms supported by said shaft, and a plurality of anodes carried by said arms and working between the series of concentric pins.

650646—May 29, 1900. F. H. LONG. *Apparatus for electrolytic reduction of ores.*

An electrolytic apparatus, the combination with a reducer vessel; its bottom cathode and a diaphragm above said cathode, of a set of dependent anodes, each consisting of a carbon head; a copper stem extended therefrom through the vessel; an incasing iron tube carried by the vessel head to sustain the anode pole; a vulcanite sheath for said tube, and suitable elastic gaskets to expansively close the joints.

653538—July 10, 1900. N. L. TURNER. *Electrolytic apparatus.*

An electrolytical apparatus, comprising a tank, rotary agitators located therein eccentrically, a series of electrodes whose main portion is concentric with the tank, while the portions adjacent to the agitators are curved concentrically with the axes of said agitators, and electrodes of opposite polarity to those first named.

654437—July 24, 1900. W. A. CALDECOTT. *Method of extracting gold from cyanide solutions containing the precious metals.*

Means for extracting gold from cyanide solutions in depositing cells, consisting in a mechanical mixture of zinc shavings and lead shavings.

656305—August 21, 1900. W. STRZODA. *Process of electrolytically extracting zinc from ores.*

The process of electrolytically extracting zinc from its ores, which consists in placing the disintegrated or pulverized ore in its natural state in an electrolytic vat containing an aqueous alkali-metal solution capable of dissolving the ore, with production of a zincate and in direct contact with the cathode, and closing the circuit through the vat, thereby precipitating zinc and the alkali metal at the cathode, the alkali metal reacting with the water to regenerate the solvent solution.

657032—August 28, 1900. A. M. ROUSE. *Apparatus for electrolyzing ores.*

In an apparatus of the class described having an anode and a cathode suitably arranged therein, the combination of a tank having an outer compartment, a tube located therein having an open upper end and provided at its lower end with openings forming communication from said compartment, a driving shaft projecting within said tube, an inner cup carried by said shaft, wings carried by said cup, an outer cup carried by said wings, a discharge duct, and a valve arranged to close said duct.

662286—November 20, 1900. E. MOTZ. *Electrolytic apparatus.*

In an electrolytic cell having open ends, the combination with a removable crossbar and means for supporting it in position, of a metallic plate covering the bottom and two sides of the bar, and forming the anode plate of the cell, of a metallic plate arranged horizontally below and parallel with the bottom of the crossbar, so as to form a passage between such plate and the bottom of the crossbar, such plate forming a cathode plate of the cell, and an auxiliary metallic cathode plate arranged vertically and parallel with the sides of the crossbar and in circuit with the horizontal cathode plate, such vertically arranged plate extending below the plane of the bottom of the crossbar, so as to more or less obstruct the said passage.

664537—December 25, 1900. J. DOUGLAS. *Process of extracting copper.*

The process of reducing copper ore and matte, which consists in electrolyzing solid cuprous chloride, employing the gases evolved in the treatment of copper ore and matte, employing the electrolyte resulting from the electrolyzing of the solid cuprous chloride as a solvent for the cuprous chloride so produced, and recovering the copper from the solution by electrolysis.

668842—February 26, 1901. A. M. ROUSE. *Apparatus for electrolytically extracting and depositing gold and silver from their ores.*

In an apparatus, the combination of a series of pulp receiving tubs, anodes and cathodes arranged in said tubs, an agitation tube having communication with said tubs at their upper and lower ends, an agitator arranged in said tube, perforated conduits located in the upper ends of said tubs, chutes located beneath said conduits onto which the ore pulp is discharged, and deflectors located beside said conduits adapted to direct the flow of pulp onto said chutes as it passes through said conduits.

669752—March 12, 1901. P. W. KNAUF. *Electrolytic apparatus.*

An element for an electrolytic series, consisting of a metallic receptacle having its lower portion of less diameter than the upper portion and having a bottom surface which is inclined upward radially from the center to the outer periphery, in combination with an exterior peripheral seat arranged below the upper edge, and an orifice adjacent to said seat.

669926—March 12, 1901. C. HOEPFNER. *Process of electrolytical extraction of metals.*

A process which consists in placing a soluble metallic anode in a solution capable of dissolving the same, placing a suitable cathode in a second similar solution containing a metal more electro-positive than that of the anode, interposing a third similar solution of less solution pressure between the two first mentioned, placing an auxiliary cathode therein, separating the solutions by suitable diaphragms, maintaining the solutions in motion and at a temperature above normal, passing a current, thereby dissolving the anode and precipitating the cathode metal at the cathode, and part of the diffused anode metal at the auxiliary cathode, precipitating the anode metal from the anode and intermediate solutions and returning the resulting solution when enriched in cathode metal to the cathode cell.

678526—July 16, 1901. C. P. STEWART. *Apparatus for the recovery of gold from cyanide solutions.*

An apparatus for recovering precious metals from flowing cyanide solutions, comprising in combination a relatively long substantially horizontal trough, means for supplying the solution at one end thereof, a partition near the receiving end of the trough for distributing the solution, a retaining partition at the discharge end of the trough adapted to retain the solution in the trough to the desired height, a body of quicksilver in the bottom of the trough between said partitions, a series of transverse anode supports extending substantially from partition to partition, a series of anodes adjustably mounted in said supports and extending down into the path of the flowing solution, and suitable electric connections.

682155—September 3, 1901. C. P. TATRO and G. DELIUS. *Electrolytic apparatus for extracting precious metals.*

In apparatus for extracting precious metals, a tub; a mercurial cathode in the bottom thereof, a principal anode, means for lowering it into and raising it out of the tub, and a minor anode permanently in the tub.

689018—December 17, 1901. W. ORR. *Method of recovering cyanides.*

The method of regenerating cyanide solutions which have become fouled by the presence of zinc and copper contained in the solutions, as double cyanide of zinc and copper with the alkaline metals which consists, first, in passing through the solution from a series of zinc anodes to a corresponding series of metallic cathodes a current of electricity; next, in introducing into such solution alkaline hydrate, being hydrate of the monovalent alkali metals and hydrate of the divalent alkali metals in the proportion of about two to one; next introducing into the solution a soluble alkali-metal sulphide, and finally removing the resulting zinc-sulphide precipitate.

689674—December 24, 1901. A. I. IRWIN. *Machine for extracting metal from ore.*

In a machine for the automatic and continuous extraction and deposition of metal from ores at one and the same time, a treatment tank, an endless anode traveling in said tank, the upper and lower stretches of the anode being in position to be immersed in the solution in the tank, diagonally disposed blocks of insulating material attached to said anode, cathodes in the tank, one under each stretch of the anode, and connections with a source of electricity.

689959—December 31, 1901. E. L. GRAHAM. *Process of disintegrating and comminuting minerals or ores.*

The process of treating ores, consisting of the following steps: First, immersing the ores in a solution of sulphuric and hydrofluoric acids incapable of dissolving the ore; second, passing an electric current of sufficient strength to disintegrate the ore through the solution; and third, extracting the metal from the ore.

699964—May 13, 1902. F. H. LONG. *Electrolytic converter.*

In electrolytic converters, the combination with the closed reducer vessel having the anode and cathode terminals and the interposed diaphragm dividing the vessel into upper anode and lower cathode chambers, of a combined separator and vent pipe connected to the cathode chamber beneath the diaphragm extending upwardly above the level of said diaphragm and having a free outlet for the gases.

700941—May 27, 1902. N. S. KEITH. *Process of treating copper or other ores for obtaining their contents of metals.*

The process of electrolyzing a solution of a metal; to deposit the metal therefrom, which consists in passing it as an electrolyte through a succession of two or more electrolytic cells, arranged so that the cells are connected in electrical series with a source of electricity; the anodes insoluble, the electrodes of each cell in electrical multiple, and having gradually increasing surfaces, whereby there is a gradual reduction of the current density as the metal of the electrolyte is deposited.

704639—July 15, 1902. C. HOEPFNER. *Leaching and extraction of metals from their ores.*

The process of extracting metals, which consists in leaching a suitable material containing copper, lead, and silver, with a warm cupric-chloride solution containing a solvent of cuprous chloride, in quantity less than is required for saturation, thereby dissolving lead and silver chlorides, precipitating them, reconverting the solution into cupric chloride, using the same for leaching fresh quantities of ore, leaching the residues with a similar hot solution more concentrated in cupric chloride, thereby dissolving copper and recovering those metals therefrom, reconverting the resulting solution into cupric chloride, and returning the latter into the cycle of operations.

706436—August 5, 1902. F. T. MUMFORD. *Apparatus for the electrolytical treatment of ores or slimes.*

An apparatus for the extraction of metals from their ores and slimes, comprising a rotatable cylindrical metallic drum, a copper lining therein, a body of mercury in the drum to maintain the lining amalgamated, a valve-controlled inlet and outlet, and a relief valve at one end, a plurality of conductive rods insulated from and passing longitudinally through the drum, a metallic ring connecting the bars, trailing electrical contact for the drum and one for said ring.

709817—September 23, 1902. C. E. DOLBEAR. *Electrolytically treating ores.*

The method of reducing metals from their ores, which consists in dissolving the crushed ore in a compound containing a nitric acid radical, adding to the mixture sulphuric acid, and subjecting the resultant compound to the action of an electric current.

725864—April 21, 1903. W. B. MCPHERSON. *Apparatus for the treatment of gold or other ores.*

A precipitating apparatus for depositing gold and silver from a cyanide of potassium solution and from other chemical solutions, comprising a precipitating box having downward, inclined bottom with openings therein, valves located in said openings, said box provided with a series of electric conducting plates vertically arranged therein and connected with a source of electric supply, a gauge receptacle, a pipe communicating with said receptacle and with the precipitating box through which the said solution passes back and forth, a float within said receptacle and adapted to reciprocate therein, a yoke secured to said float, a horizontally reciprocating valve rod, devices for connecting said yoke with said valve rod, means for operating said valves in connection with valve rod, and means for conveying said solution from said precipitating box and returning the same thereto.

737554—August 25, 1903. L. P. BURROWS. *Electrolytic apparatus.*

An electrolytic apparatus, comprising a dissolving vessel having a revoluble anode, a depositing vessel having a cathode, means for conveying an unbroken stream of liquid from the dissolving vessel, and an electric circuit including said anode and cathode, whereby the electric current is caused to traverse the stream of liquid flowing from the dissolving vessel into the depositing vessel.

741231—October 13, 1903. W. H. DAVIS. *Process of treating cyanide solutions.*

The process for treating cyanide solutions during or subsequently to their contact with the ore, consisting in introducing into the solution an alkaline hydrate and then subjecting the mixture to the action of an alternating electric current, thereby raising the osmotic pressure to dissociate the double salts in the solution, causing precipitation of the hydrates of the base metals and to combine the freed cyanogen with the alkaline hydrates to cause simultaneous regeneration of the cyanide in the solution and clarifying of the latter.

741439—October 13, 1903. C. E. BAKER and A. W. BURWELL. *Process of treating ores.*

The process of recovering copper and nickel from a solution of sulphates of copper, nickel, and iron, which consists of electro-depositing the copper, neutralizing the solution, and electro-depositing the nickel with a current density insufficient to deposit the iron.

743668—November 10, 1903. R. SUCHY and H. SPECKETER. *Extracting chromium from chrome-iron ore.*

The process of making soluble chrome-iron ore and obtaining chromium compounds, which consists in heating the ore together with sulphuric acid in excess and an oxidizing agent and separating by filtration the precipitated insoluble ferrisulphate from the chromosulpho acid.

749843—January 19, 1904. H. R. CASSEL. *Process of extracting precious metals by electrolysis.*

The process of extracting precious metals by electrolysis, which consists in circulating the pulp between vertical electrodes, amalgamating a vertical cathode, successively deflecting the rebounding mercury back upon said cathode, removing the amalgam, neutralizing the alkali in the mercury, and returning the mercury to the cathode.

749844—January 19, 1904. H. R. CASSEL. *Apparatus for extracting precious metals by electrolysis.*

An apparatus for extracting precious metals by electrolysis, comprising a tank, inclosed vertical electrodes, mercury deflectors, and pulp guards at the sides of the cathode, an elevated pulp box, communicating perforated launders, means for lifting the pulp into said box, an elevated mercury pot, communicating slidable perforated troughs, and means for lifting the mercury into said pot.

755302—March 22, 1904. E. A. LE SUEUR. *Extraction of copper from comminuted mineral mixtures.*

The method of obtaining metallic copper from mixtures containing it, which consists, first in treating said mixtures with an ammoniacal solution containing a cupric compound or compounds, so as to dissolve the desired copper, then in removing a portion of the total copper contents of the solution, and lastly in using the partially exhausted solution over again to dissolve fresh copper as before.

QUICKSILVER

(647)

QUICKSILVER.

By Joseph Struthers, Ph. D.

The production of quicksilver in the United States during 1902 was confined to the states of California and Texas. In 1889 production was reported only from California and Oregon. Table 1 shows the comparable items for the census years of 1902 and 1889.

Table 1.—*Comparative summary: 1902 and 1889.*

	1902	1889
Number of mines	41	17
Number of operators	37	11
Salaried officials, clerks, etc.:		
Number	117	20
Salaries	$154,154	$34,966
Wage-earners:		
Average number	1,329	961
Wages	$881,340	$591,323
Contract work	$23,164	(1)
Miscellaneous expenses	$59,767	$35,490
Cost of supplies and materials	$322,267	$219,622
Product:[2]		
Total value	$1,550,090	$1,190,500
Quicksilver—		
Quantity, flasks	34,291	26,464
Value	$1,467,848	[3]$1,190,500
Cinnabar—		
Quantity, short tons	11,727	2,750
Value	$82,242	(1)

[1] Not reported.
[2] The United States Geological Survey reports $1,467,848, which does not include 11,727 short tons of cinnabar, valued at $82,242, mined but not reduced.
[3] Exclusive of 20 flasks, valued at less than $1,000, produced in Oregon.

The quantity of quicksilver produced in 1902 showed an increase of 29.6 per cent over that reported at the Eleventh Census. There were 11,727 tons of cinnabar reported, valued at $82,242, which was not reduced. The amount of mechanical power decreased 17 per cent. The growth in the number of wage-earners and in the wages paid them appears to have been normal. The increase in the amounts expended for supplies and materials, and for miscellaneous expenses also, is a normal growth.

Idle mines reported for 1902 numbered 56—50 in California, 3 in Oregon, and 3 in Texas. There were 10 operative mines for which no production was reported, the employees being engaged in development work. Seven of these mines were located in California and 3 in Oregon. The statistics for these nonproductive mines are summarized in the following statement. Among the owners of the idle mines and those for which development work was reported, were 7 incorporated companies, with a total par value of stock issued amounting to $10,683,000.

Development work: 1902.

Number of mines	10
Number of operators	9
Salaried officials, clerks, etc.:	
Number	8
Salaries	$9,525
Wage-earners:	
Average number	35
Wages	$27,498
Contract work	$150
Miscellaneous expenses	$955
Cost of supplies and materials	$7,169

Capital stock of incorporated companies.—Table 2, which follows, shows that 21 operators, or 56.8 per cent of the total number, were incorporated companies, and gives their capitalization.

Table 2.—*Capitalization of incorporated companies: 1902.*

Number of incorporated companies	[1]21
Capital stock and bonds issued	$39,017,700
Capital stock:	
Total authorized—	
Number of shares	2,222,620
Par value	$44,100,000
Total issued—	
Number of shares	2,136,143
Par value	$38,872,700
Dividends paid	$171,994
Common—	
Authorized—	
Number of shares	2,179,620
Par value	$39,800,000
Issued—	
Number of shares	2,093,143
Par value	$34,572,700
Dividends paid	$150,494
Preferred—	
Authorized—	
Number of shares	43,000
Par value	$4,300,000
Issued—	
Number of shares	43,000
Par value	$4,300,000
Dividends paid	$21,500
Bonds:	
Authorized—	
Number	1,450
Par value	$145,000
Issued—	
Number	1,450
Par value	$145,000
Interest paid	$6,000
Assessments levied	$178,500

[1] Includes 18 in California and 3 in Texas.

The par value of capital stock, common and preferred, and of bonds issued, amounted to $39,017,700. This seems excessive for an industry producing a product valued at only $1,550,090. The dividends paid on the stock were small, amounting to $150,494 on the common and $21,500 on the preferred. The interest paid on bonds was $6,000. The dividends paid on the common stock amounted to four-tenths of 1 per cent of the par value of all common stock issued. The dividend on the preferred stock was five-tenths of 1 per cent on the total amount issued.

Employees and wages.—The average number of wage-earners employed each month, as given in Table 8, was remarkably uniform, varying only from 1,303 in July and August to 1,358 in November, a difference of 55. In this respect the industry presents a uniform operation, due to the fact that the demand for cinnabar and mercury is steady, and that the mines reported were located in California and Texas, where the climate permits of uninterrupted working. Child labor is relatively unimportant, amounting to about one-half of 1 per cent of the whole number of wage-earners.

The daily rates of pay at which the workmen engaged in the various occupations were employed are also given in Table 8. Miners constituted 46.2 per cent of the total number of wage-earners, and of all miners 75.4 per cent were employed at rates not less than $1.75 per diem. Of the 38 engineers reported, all received $2 or more per diem, and the same is true of 35 out of the total of 42 firemen. Miners' helpers formed an important class, constituting 17 per cent of the total number of wage-earners. These workmen had various duties and their rates of pay ranged from 75 cents to $2.99 per diem. The timbermen and track layers received good wages, 11 receiving from $2 to $2.24, and 7 from $3 to $3.24 per day. The class "all other wage-earners" is chiefly composed of ordinary laborers. Of these workmen 43.7 per cent received less than $2 per diem, while 56.3 per cent received $2 or more.

Mechanical power.—Primary power aggregating 1,808 horsepower was reported. This was applied chiefly through steam engines, of which there were 56 reported, or an average horsepower of 28. Over 8 per cent of the total power was furnished by 17 gas or gasoline engines. Three water wheels were reported, representing 22 horsepower. Sixty horsepower was supplied by 5 air compressors. There were also 3 electric motors with 15 horsepower.

Production in the United States.—The quicksilver produced in the United States during 1902 amounted to 34,291 flasks of 76.5 pounds each, aggregating 1,189.9 metric tons, and valued at $1,467,848, as compared with 26,464 flasks, 918.3 metric tons, valued at $1,190,500 in 1889. This shows an increase in quantity of 7,827 flasks, and in value of $277,348, over the statistics at the Eleventh Census.

Mercury is transported in cylindrical wrought iron flasks, each 5 inches in diameter and about 14 inches long, closed with a screw plug, and having a capacity in the United States of 76.5 pounds. At Almaden, Spain, and Idria, Austria, the capacity is slightly less, being 76 pounds.

Of the 34,291 flasks produced in the United States during 1902, California contributed 28,972 flasks, or 84.5 per cent, and Texas 5,319 flasks, or 15.5 per cent. Except as noted below, the entire output of quicksilver in the United States has been derived from California, and statistics of production and the average value per flask for that state during the period from 1889 to 1902, inclusive, are given in Table 3, as reported by the United States Geological Survey. In addition to the output of California, the following quantities have been produced in Texas and Oregon: Texas, in 1899, 261 flasks; in 1900, 750 flasks; in 1901, 2,932 flasks; and in 1902, 5,319 flasks; Oregon, in 1900, 233 flasks and in 1901, 75 flasks.

TABLE 3.—*Production of quicksilver in California and the average price per flask at San Francisco: 1889 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR.	Quantity (flasks each containing 76.5 pounds).	Average price per flask.
1889	26,464	$45.00
1890	22,926	52.50
1891	22,904	45.25
1892	27,993	40.71
1893[1]	30,164	36.75
1894	30,416	30.70
1895	36,067	37.04
1896	30,765	34.96
1897	26,691	37.28
1898	31,092	38.23
1899	29,454	47.70
1900	26,317	44.94
1901	26,720	48.46
1902	28,972	43.20

[1] Beginning with 1893, figures taken from Annual Statistical Bulletin of the California State Mining Bureau.

Prices.—The price of quicksilver in the United States is affected by several conditions, chiefly the quantity available and the mode of disposition of the product, whether for home consumption or for export. In the latter case a relatively low price is obtained for the metal, as it has to compete in foreign markets with the European product. In some cases the prices vary according to the rates of transportation from the various entry ports to the points of consumption, in order to compete with the European product which may enter at other ports; thus, comparatively higher export prices are obtained at western coast ports of Mexico than at interior points of consumption adjacent to railroads leading to eastern ports.

The average monthly price of quicksilver, per flask, during 1902, as reported by the United States Geological Survey, is given in Table 4. The lower averages during 1902 indicate the periods of largest sales for export, and the higher averages indicate periods of sales for domestic consumption.

TABLE 4.—*Average monthly price of quicksilver per flask at San Francisco during 1902.*

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

MONTH.	Price.	MONTH.	Price.
January	$45.30	August	$42.71
February	44.29	September	42.35
March	45.56	October	42.37
April	45.00	November	42.64
May	44.83	December	45.00
June	45.77		
July	43.39	Average	44.10

The average monthly price of quicksilver, per flask, at New York during 1902 was $48.37 for January, and $48 for the other months of the year.

Imports and exports.—The quantity of quicksilver imported during the past decade has been inconsiderable, owing to the fact that in this period approximately one-half of the domestic product has been exported. For the past five years the quantities imported have been merely nominal.

Table 5, published by the United States Geological Survey from statistics of the United States Treasury Department, shows the quantity and value of the annual imports of quicksilver from 1889 to 1902, inclusive, and Table 6, from the same source, shows the quantity and value of the exports of quicksilver during the period 1889 to 1902, inclusive. Prior to 1901 very nearly the entire quantity of quicksilver exported was shipped from San Francisco, but in that year only 5,479 flasks of the total of 11,219 flasks exported were shipped from that port, practically the entire exportation being consigned to Mexico and Central America.

TABLE 5.—*Quicksilver imported and entered for consumption in the United States: 1889 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR ENDING DECEMBER 31—	Quantity (pounds).	Value.
1889	341,514	$162,064
1890	802,871	445,807
1891	123,966	61,855
1892	96,318	40,133
1893	41,772	17,400
1894	7	6
1895	15,001	7,008
1896	805	118
1897	45,539	20,147
1898	81	51
1899	131	83
1900	2,616	1,051
1901	1,441	789
1902	(1)	2,166

[1] Not stated.

TABLE 6.—*Exports of quicksilver from the United States: 1889 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

YEAR.	Quantity (flasks).	Value.
1889	5,111	$213,717
1890	2,069	93,492
1891	3,714	145,502
1892	3,518	133,626
1893	16,631	542,410
1894	14,408	397,528
1895	15,542	482,085
1896	19,941	618,487
1897	13,173	394,549
1898	12,830	440,587
1899	16,517	609,586
1900	10,172	425,812
1901	11,219	475,609
1902	13,247	575,099

Production in the principal producing countries of the world.—The following table gives the production, in metric tons, and the value of quicksilver in various countries in the years 1899, 1900, and 1901, as reported by the United States Geological Survey:

TABLE 7.—*World's production and value of quicksilver in 1899, 1900, and 1901.*[1]

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

[Metric tons.]

COUNTRY.	1899		1900		1901	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
United States	1,057	$1,452,745	983	$1,302,586	1,031	$1,382,305
Austria	536	492,021	510	499,052	525	547,513
Italy	205	246,000	260	312,000	278	361,400
Russia	362	321,814	304	270,256	(2)	(2)
Spain	1,361	1,481,229	1,095	1,193,550	754	1,105,890
Total	3,521	3,993,809	3,152	3,577,444	2,588	3,397,108

[1] Mexico exported 324 tons of quicksilver in 1899, 335 tons in 1900, and 335 tons in 1901.
[2] Statistics not yet available.

A detailed summary showing the statistics for quicksilver during 1902 is given in Table 8.

DESCRIPTIVE.[1]

Historical.—Mercury or quicksilver has been known to mankind from very early times. No mention of it appears, however, in the books of Moses or in the works of the early Greek writers. The earliest known reference is in the writings of Theophrastus (300 B. C.), who speaks of liquid silver or quicksilver. Dioscorides refers to artificial mercury as ὑδράργυρος, water silver; Pliny gave it the name of *hydrargyrum* in contradistinction to native mercury, which he called *argentum vivum*. The name quicksilver was undoubtedly suggested by the liquid form and silver color of the metal, while that of mercury was derived from the name of the Greek god Mercury, probably in allusion to the quickness and ease with which it flows in any direction. The salts of mercury also were known at a very remote period. The early Arabians were familiar with mercurous chloride (Hg_2Cl_2), or calomel, and mercuric oxide (HgO), the red oxide, and the alchemists possessed a knowledge of mercuric chloride ($HgCl_2$), corrosive sublimate. The mineral cinnabar, mercuric sulphide, has been used as a pigment from the most ancient times on account of its enduring vivid red color. By reason of its peculiar physical properties in being liquid, very heavy, and not acted on by air, sulphuric acid, or hydrochloric acid, mercury perhaps more than any other metal has excited the attention and curiosity of experimenters.

Physical and chemical characteristics.[2]—The symbol of mercury (Hg) is derived from the old Latin name *hydrargyrum*. Its atomic weight is 199.8. Aside from bromine, mercury is the only elementary metal which exists in a liquid form at ordinary tempera-

[1] In this paper the older term "quicksilver" has been retained for use in connection with the description of the mining and metallurgy of the metal, as it is the name generally accepted by the public. The modern name "mercury" has been reserved for the description of the physical and chemical properties of the metal.
[2] Inorganic Chemistry, Newth, page 554 ff.

tures. It is a bright tin-white liquid, and, when free from impurities, the globules retain a perfectly spherical shape. The luster is mirror like, and like that of silver it is preserved in air free of sulphurous gases. Mercury, when cooled to a temperature of $-38.8°$ C., is transformed into a tin-white, ductile, malleable mass, softer than lead and crystallizing in octahedrons. During the cooling it contracts uniformly until the temperature of solidification is reached, at which point a considerable contraction takes place, and, as a consequence, the solidified mercury will sink below the surface of liquid mercury. At 0° C. the specific gravity of mercury is 13.596 and at $-38.8°$ C. the specific gravity of solidified mercury is 14.193. In very thin films the liquid metal is transparent and of a violet-blue color when viewed by transmitted light.

The specific heat of solidified mercury (between $-78°$ C. and $-40°$ C.) is 0.0247; that of liquid mercury (between 0° C. and 100° C.) is 0.0333. Its thermal conductivity is 667, compared with that of silver taken at 1,000, and its electrical conductivity at 22.8° C. is 1.63, silver at 0° C. being taken at 100.

The boiling point of mercury at the standard pressure of 760 mm. is 357.25° C. Above this temperature it becomes a transparent, colorless vapor, having a density of between 6.7 and 7.03, referred to air as a unit. The density of gaseous mercury compared with hydrogen is 100.92, and as its atomic weight is 199.8, this element in a gaseous form consists of monatomic molecules. Mercury gives off vapors at all temperatures. This may be illustrated by suspending a piece of gold leaf above the surface of mercury in a stoppered bottle; the gold leaf will slowly assume a white color from the formation of gold amalgam on the surface.

In its liquid and gaseous forms mercury is poisonous, producing salivation when taken either internally through the lungs or stomach or by absorption through the pores of the skin. Mercury is not tarnished by exposure to the air, nor is it acted on by many gases; hence it is an invaluable aid to the chemist in the collection and measurement of gases which are soluble in or absorb water. When subjected to prolonged heating in the air, mercury is slowly transformed into red mercuric oxide (HgO), which at a higher temperature is again decomposed into its elements—mercury and oxygen.

Liquid mercury is converted by agitation with oil or by trituration with sugar, chalk, or lard into a dull-gray powder. This process is called "deadening," and is used to prepare mercurial ointment, the gray powder consisting simply of very finely divided mercury in the form of minute globules.

Mercury is not attacked by hydrochloric acid. Concentrated sulphuric acid has no action on it in the cold, but rapidly dissolves it when heated, yielding sulphur dioxide gas. Diluted nitric acid dissolves it slowly when cold, forming mercurous nitrate, and concentrated nitric acid attacks it rapidly, forming mercuric nitrate and fumes of oxides of nitrogen.

In commerce mercury is usually contaminated with a small proportion of dissolved metals, which cause a globule to lose its spherical shape and drag a tail behind it while flowing over an inclined surface. If the mercury is shaken in the air, these metallic impurities become oxidized and form a black powder or scum, which incloses small drops of the metal, thus preventing them from coalescing. Mercury in this condition is said to be "floured." Commercial mercury is best purified by distillation, but for ordinary purposes the impurities may be removed almost entirely by repeated agitation with dilute nitric acid or perchlorate of iron, either of which attacks the impurities and forms with them soluble nitrates and chlorides, respectively, which are removable by washing with water.

Occurrence.—Mercury is found in nature chiefly as the ore cinnabar, mercuric sulphide (HgS or Hg_2S_2). It occurs also, though less commonly, as native mercury, which is disseminated in many cinnabar deposits in the form of fine globules, sometimes in large quantities. From a commercial standpoint, cinnabar and metallic mercury are the only ores of importance.

The following is a list of all the known ores of mercury, classified according to composition:

List of the mercury ores.

CLASS.	Mineral name.	Composition.
Native mercury	Native mercury	Hg.
Amalgams (silver)	Amalgam	AgHg or Ag_3Hg_3.
	Arquerite	$Ag_{12}Hg$.
	Kongsbergite	$Ag_{36}Hg$.
Amalgams (gold)	Gold amalgam	$(AuAg)_2Hg_5$.
Sulphides	Cinnabar	HgS or Hg_2S_2.
	Metacinnabarite	HgS or Hg_3S_3.
	Hepatic cinnabar or "liver ore."	HgS or Hg_2S_2, with carbon and clay.
	Livingstonite	$HgS_2 Sb_2S_3$.
	Ammiolite	HgSb CuS and Fe.
	Barcenite	HgSb S and Fe.
Sulpho-selenides	Onofrite	Hg(S, Se).
	Guadalcazarite	Hg(S, Se).
	Leviglianite	Hg(S, Se) with Fe.
Selenides	Tiemannite	HgSe.
	Lehrbachite	(HgPb) Se.
Tellurides	Coloradoite	HgTe.
	Magnolite	$Hg_2Te O_4$.
Chloride	*Calomel*	Hg_2Cl_2.
Oxychlorides	Terlinguaite	Hg_2ClO.
	Eglestonite	$Hg_6Cl_3O_2$.
Iodides	Coccinite	HgI.
	Tocornalite	(HgAg) I.
Oxide	Montroydite	HgO.

Important compounds of mercury.—With most metals mercury forms a series of alloys called amalgams; in some cases, as with the alkali metals, the formation of the alloy is attended with a rise of temperature, while in other cases, as with tin, an absorption of heat results. Sodium and potassium amalgams are decomposed by contact with water, yielding hydrogen gas and an alkaline hydroxide; for this reason sodium amalgam is used in the laboratory as a reducing agent. Zinc amalgam is acted upon very slowly by dilute sulphuric acid, and on this account the surface of zinc plates in galvanic batteries is usually amalgamated. Tin amalgam is used to produce the reflecting surface of ordinary mirrors, and amalgams of gold, copper, and zinc are used in dentistry as fillings for teeth.

In addition to the amalgams, mercury forms the following commercially important compounds: With chlorine, mercurous chloride ($HgCl$), or calomel, largely used in medicine, and mercuric chloride ($HgCl_2$), or corrosive sublimate, used in medicine, and in surgery as an antiseptic, and also in the preparation of anatomical specimens, and in the dressing of furs and skins; with oxygen, mercurous oxide (Hg_2O), the suboxide or gray oxide of mercury which is of little importance commercially, and mercuric oxide (HgO), the red oxide of mercury or red precipitate, used in medicine and for various purposes in chemical analyses; with sulphur, cinnabar, mercuric sulphide (HgS), or vermilion, the same as cinnabar, the chief ore of mercury. Vermilion is invaluable as a pigment, because of the permanence of its vivid cochineal-red color. It is made artificially in two ways—one, termed the dry method, in which an intimate mixture of metallic mercury and sulphur in proper proportions is heated in a retort and the sublimed product condensed and ground very fine, the beauty of the tint depending largely upon the fineness of the material; and the other, called the wet method, by which various compounds of mercury are transformed into the sulphide by the use of chemical reagents. Vermilion prepared by the wet method is of better quality than that made by the dry process. The manufacture of vermilion has declined in recent years on account of the competition of cheaper pigments which have supplanted its use. The most important of these is "orange mineral" (red lead), which is toned up to the proper color by the use of eosin, one of the aniline dyes. These imitation vermilions are now employed for almost all of the more common uses, such as wagon painting, and while they are inferior to the true mercury vermilion, from the fact that they fade on exposure, yet they are a fairly satisfactory substitute as long as they are protected by an exterior coating of varnish. Mercury vermilion is now used chiefly for red colors in oil paintings, lithography, etc.

The extraction of mercury from its ores.—Mercury is extracted by heating the ore in a retort or a furnace; the metal is expelled as a vapor, which is subsequently condensed in cooling chambers and collected.

Up to the present time mercury has been extracted from its ores solely by the dry process. Various chemical and electrolytic methods have been proposed repeatedly and numerous experiments made, but without commercial success.

Perhaps the development of electric current generated by waterpower in localities where the use of fuel is nearly or quite prohibitive will render profitable the extraction of the metal by some electrolytic process.

The principal ore of mercury, as already stated, is cinnabar, mercuric sulphide, accompanied at times with minute globules of native mercury. The metal may be extracted from the ore by a simple distillation, either in a retort or in a shaft furnace, and though mercury may be separated from cinnabar in numerous ways, only two methods are now used on a large scale. One is based on the decomposition of the ore at a high temperature by air, forming metallic mercury and sulphur dioxide gas in accordance with the reaction: $HgS+O_2=Hg+SO_2$ (360° C.). The other accomplishes the decomposition by the use of lime or iron which combines with the sulphur and sets free the mercury in accordance with the reactions: $4HgS+4CaO=4Hg+3CaS+CaSO_4$, and $HgS+Fe=FeS+Hg$, respectively. These chemical decompositions take place at temperatures above the boiling point of mercury so that the latter is expelled in gaseous form and subsequently condensed and collected in cooling chambers.

In present furnace practice the heat necessary for the decomposition of the ore, either with or without the admixture of lime or iron, is applied in two ways—first, by heating the ore charge in a tightly sealed iron retort, which produces the mercurial vapor undiluted with furnace gases; and second, by treatment in a large furnace, where the products of combustion come in direct contact with the ore and pass out of the furnace in the form of sulphur dioxide gas, nitrogen, and unused air, mixed with the expelled mercurial gases, from which the metal is obtained by condensation in the cooling chambers. Thus the essential difference between the two methods is that the vapors given off in the retort furnaces are entirely separate from the furnace gases of combustion. The retort method possesses the advantage of yielding the mercurial vapor in a concentrated and easily condensible form, which is more than offset, however, by the high cost of fuel and labor involved and the small size of a single charge. At present the use of iron retorts is restricted to exceptionally rich ores and mercurial soot and concentrates.

The furnaces now generally used in California are of the shaft type, into which the ore is fed continuously. There are two kinds of these furnaces—one called the "coarse-ore" furnace, used for treating lump ore, and the other the "tile" furnace for medium-sized and fine ores. There are many differences in the details of the construction of coarse-ore shaft furnaces, but in general they consist of a cylindrical brick shaft, into which the ore is charged at the top, while the cinders are removed at the bottom. The heat necessary for the reaction is supplied at or near the bottom of the shaft, the gases of combustion passing through the ore column, and, together with the liberated mercurial vapors, pass out from the furnace through a pipe at the top and are led to the condensing plant. The general type of tile furnace consists of a number of narrow rectangular shafts, each having a series of tiles inclined inward and downward and so placed alternately on the longer sides that the fine to medium sized ore (up to 3.5 inches in diameter) will follow a zigzag path in its descent, until it is finally discharged at the bottom through the drawing pit. The ore is gradually heated in its descent by the products of combustion from the fuel burned in the fireplaces at or near the bottom of the furnace.

The condensing plant generally consists of a cooling device and a condensing chamber in which the liquefied mercury is deposited. The gases passing out from the furnace must necessarily be of a temperature higher than the boiling point of mercury (357.25° C.), and the mercury content of these gases by volume is often less than 1 per cent. In addition to the products of combustion of the fuel and the mercurial vapors, these furnace gases contain sulphur dioxide, which is derived from the decomposition of the ore, which when cooled yields acid liquors that attack ordinary materials of construction. In the construction of the condensing apparatus for the proper cooling and condensation of the mercury three factors must be taken into consideration: The distance the gas has to travel, the interior capacity of the chamber, and the area of the cooling surface. The details of adjusting the construction of the condenser to give the best results vary at each plant. The materials used in building the condensers should be nonabsorbent of mercurial vapor, good conductors of heat, not affected by acid vapors or liquors, and capable of being molded into the required form. No one substance answers all requirements. Iron is a good conductor of heat and may be easily shaped, but it does not resist the corrosive action of the acid vapors, and to overcome this disadvantage the iron pipes are often protected from corrosion by a coating of cement. Brick absorbs mercurial vapors, is attacked by acids, and is a bad conductor of heat. Wood will resist acid, but is a bad conductor of heat, and can not be placed near the furnace where the temperature of the gases is high. Glazed stoneware resists the action of acid and mercury, and may be made thin in order to offset its poor heat-conducting qualities. As with the variations in the selection of the materials of construction used, so is it with the general arrangement of the condensing plant.

Uses.—The most important commercial use of mercury is in the extraction of gold and silver from certain ores by the amalgamation process; the precious metals becoming alloyed with the mercury, form a heavy amalgam, which is separated by gravity from the fine sands and the "tailings" of the ore suspended in water. Owing to the avidity with which mercury combines with impurities, thereby becoming subdivided into innumerable minute globules which will not coalesce, considerable quantities of the metal are lost during the amalgamation process, by being held in suspension in the water, and washed away with the sands and the tailings.

In the chemical industries large quantities of mercury are used as electrodes in several electrolytic processes, notably in the electrolysis of brine to form sodium salts. The solution of salt having been decomposed by the electric current, the metallic sodium thereby set free at the cathode immediately combines with the mercury, from which the sodium is subsequently extracted by a treatment with water, forming sodium hydroxide (caustic soda). On account of its high specific gravity, and its freedom from attack by many gases, mercury is an invaluable material for the construction of liquid seals in gas collecting apparatus, for making thermometers and barometers, and for making electrical contacts in certain apparatus used in physical laboratories and industrial processes.

REVIEW OF THE QUICKSILVER INDUSTRY IN THE UNITED STATES DURING 1902.

The quicksilver deposits of commercial importance in California are situated in the Coast Range and are limited to an area bounded by Trinity county on the north and San Luis Obispo county on the south, both counties being included. During 1902 San Benito county contributed 7,289 flasks, valued at $306,096, the product being derived largely from the New Idria mine. Development work was carried on during the year at the Cerro Benito and the Pichaco mines. In Napa county the chief producer was the Napa Consolidated mine at Oat Hill. In the Knoxville district the Boston mine, formerly the Readington mine, under the control of the Boston Quicksilver Mining Company, and the Manhattan mine contributed to the output. The total production for Napa county during the year amounted to 7,300 flasks. Santa Clara county was next in the order of quantity produced, contributing 5,779 flasks. The chief producer in this county was the New Almaden mine, followed by the Guadalupe mine. The New Almaden mine is the oldest quicksilver mine in the United States. It was discovered and worked in 1824, when California was under Mexican rule, and was then known as the Chaboya mine. Later it was abandoned until 1845, and since 1850 it has been worked continuously. Furnaces were erected at the Santa Teresa and the Summit mines. San Luis Obispo county supplied 2,546 flasks, the chief producer being the Karl Quicksilver Mining Company. A new Scott furnace was installed and put in operation at the Oceanic mine, and development work was actively carried on at a number of smaller properties, notably the Alice, Modoc, Libertad, Madrone, Pine Mountain, and Stayton mines. Lake county furnished 3,797 flasks, obtained chiefly from the Great Western mine. The Sulphur Bank and Abbott mines, controlled by the Empire Consolidated Quicksilver Mining Company, were in litigation during the year. The Helen mine furnished a small quota, and promising development work was done at the Bullion mine, operated by the Standard Company. From Colusa county a considerable product was obtained from the Manzanite mine, Sulphur creek, where a successful process of ore concentration was operated. In Sonoma county the chief producer was the Great Eastern Quicksilver Mining Company. The total output of the county during the year was 1,519 flasks. A number of old mines were reopened in the Pine Flat district. Other producing mines were the Cloverdale, the Great Western, and the Socrates. Development work of the Pacific Company on property adjoining that of the Crystal Company was so satisfactory as to warrant the erection of a furnace to treat the ore. A new modified Livermore furnace was completed at the Culver Bear property. In Trinity county, which contributed a small amount to the total output during the year, the Altoona Company treated ore from the surface workings and the dumps. Considerable development work was accomplished by the Boston, Integral, and several minor concerns. The balance of the total output of California was obtained in Solano county. Several new mines were added to the list of producers during 1902; those contributing an output of 100 flasks or more being the Helen mine in Lake county, and the Silver Creek mine in Santa Clara county. Other quicksilver companies reported to have started operations in 1902 were the Monterey Quicksilver Mining Company, near Idria, San Benito county; the Modoc Chief mine, near Redding, Shasta county; the Mariposa and Elizabeth mines, and the Uncle Sam and Eureka mines, near Cambria, San Luis Obispo county; and the Summit, Adobe Valley, and Orestimba properties, in Stanislaus county. A deposit of quicksilver ore of good quality was reported in Modoc county, 25 miles east of Cedarville, in the extreme northwestern part of the state—an entirely new section for the occurrence of cinnabar.

As to the future of the quicksilver mining industry of California the larger and better known mines have in a measure been worked out, and it is hardly within the range of probability that other mines equal in extent to the New Almaden or the New Idria will be discovered. Yet, on the other hand, there are many smaller mines which, by contributing from 20 to 300 flasks each per month, supply a considerable quantity of metal in the aggregate. Furthermore, the improvement in metallurgical and mining practices during recent years, which permits the profitable treatment of very lean ores, will probably maintain the quicksilver industry in an important economic position for many years to come. It is stated in general that quicksilver can be produced in California at a mining and smelting cost of $3 per ton of ore, which renders it possible to treat with profit ores containing from 0.3 to 0.6 per cent of quicksilver; in a few cases it is possible to treat even lower grade ores and yet make a profit. The general statement is made that a modern furnace, operating on average ores, produces quicksilver at a cost of $35 per flask not including interest on capital invested in the plant and property, or the cost of development work at the mine.

In Oregon the sole producer of quicksilver in recent years has been the Black Butte Quicksilver Mining Company, which opened a quicksilver mine in 1898 on a spur of the Cascade mountains at Black Butte, Lane county. A modern 40-ton shaft furnace of the inclined shelf type was installed, but after a few months it was closed for alterations, the condensation of the quicksilver being too imperfect to render the smelting profitable. Operations were resumed in 1900. In that year the above-named company acquired the Elkhead mine, in Douglas county, 5 miles from Black Butte; this mine was equipped with a 10-ton Scott furnace. Considerable development work has been reported by this concern, but the operations have not been entirely successful, as only 75 flasks of quicksilver were produced in 1901 and none in 1902. The ore of the Black Butte mine is of low grade, the average rarely exceeding one-half of 1 per cent of quicksilver.

The principal operating companies in Texas in 1902 were the Marfa and Mariposa Mining Company, with three 10-ton Scott furnaces; the Terlingua Mining Company, with one 40-ton Scott furnace; and the Colquitt-Tigner Mining Company, with one 10-ton Scott furnace.

The cinnabar deposits of California Hill, Brewster county, near Terlingua post-office, 90 miles southeast of Marfa, were known to the Comanche Indians, who used them as a vermilion pigment. The knowledge of these deposits, however, was not recorded until 1894, when several Mexicans found a few pieces of cinnabar float and took them to San Carlos, on the Mexican side of the Rio Grande, whence they were sent to Chihuahua, and their mineralogical character determined. Mr. George W. Wanless, of the Rio Grande Smelting Works, and Mr. Charles Allen, of Socorro, N. Mex., under the direction of the Mexicans, found the veins and located the first mineral claims. Shortly after this Prof. William P. Blake described these deposits under the title "Cinnabar in Texas,"[1] the first important article concerning this subject on record. Considerable prospecting work was carried on in the district, but it was not until 1898 that the metal was produced in commercial quantities. In that year Lindheim & Co. made a few flasks of quicksilver in a crude furnace at Terlingua. Other concerns became interested in the development of the quicksilver deposits, and the output of the region was 270 flasks in 1899, 750 flasks in 1900, 2,932 flasks in 1901, and 5,319 flasks in 1902, thus making a total output of 9,271 flasks.

The deposits of cinnabar at Terlingua are of two classes; one occurs in hard and durable limestone and the other in soft and friable argillaceous beds. The ores are cinnabar, mercury, yellow sulphide, and terlinguaite, and contain in addition several other mercury minerals, such as calomel, eglestonite, and montroydite, which, on account of their rarity, are of scientific interest only. Cinnabar is the principal mineral and is usually mixed with clay or iron oxide. Native mercury is present in several localities in the district, occurring in the interstices of crystalline calcite, and a single cavity in the calcite veins has yielded as much as

[1] Transactions of the American Institute of Mining Engineers, Vol. XXV (1895), pages 68 to 76.

20 pounds of the native metal. The associated gangue is composed of calcite, aragonite, gypsum, and occasionally a little barite; iron oxide, pyrite, and occasionally arsenic and manganese minerals.

The methods of mining in the Terlingua district up to the present time have been extremely crude. The workings have been confined mainly to the open cuts on the surface, but a few shafts have been sunk to a depth of from eighty to ninety feet and the ore obtained by drifting along the vein. The material mined is carried to the surface in rawhide buckets on the backs of Mexican miners, who climb notched-pole ladders with great agility. The veins are generally quite narrow, often less than one foot in width. The mined ore is sorted by hand, arranged into piles according to richness, and transported to the furnace plant, where it is first crushed in a Blake crusher, operated by gas engines, which are more convenient than steam engines on account of the lack of water and fuel. The crushed ore is then conveyed to the ore bins, which are situated above the level of the furnace, and from there, as required, it is dumped into cars and charged into the furnace through hoppers.

Formerly the very rich ore was treated in a retort, a method so wasteful and entailing such costly repairs that it has been supplanted almost entirely by shaft furnaces of the continuous type similar to the Scott-Hüttner furnace used in California. The greater part of the ore is treated in a shaft furnace by air oxidation, in some cases lime being added to aid in the decomposition of the sulphide. A very small proportion, consisting of extremely rich pieces, is treated in a furnace of the retort type.

The development of the quicksilver mines in this region has been seriously hampered by the scarcity of water and the lack of fuel, mesquite wood being about the sole supply of the latter. However, coal and asphaltum have been found within a few miles of Terlingua, and there is a possibility that oil may be discovered, as the formation closely resembles that of the Corsicana oil fields.

THE QUICKSILVER INDUSTRY IN FOREIGN COUNTRIES.

In Spain, 90 per cent of the total production of quicksilver is obtained from the Almaden mines, in the province of Ciudad Real, which have been worked intermittently during the past two thousand years. The mines are owned by the Government, and the output is controlled by the Rothschilds, who have been operating the mines under a ten-year concession, which was continued in 1900. The ores are very rich, averaging about 8 per cent of metal. The furnaces are not operated during the hot season, from May to September. Mining is conducted with a view to permanency, and masonry is freely used in the various galleries and chambers of the mines. It was not until 1896 that machine drills were installed.

In Austria, the cinnabar deposits of Idria, in Krain, were first mined in 1490, and shortly afterwards were placed under Government ownership and supervision. These mines furnish by far the greater part of the total output of quicksilver in Austria, only a small quantity being supplied by the mines in Hungary. The ore of the Idria mines is separated by hand into three classes, namely, (1) a small proportion of high grade ore, containing about 8.5 per cent of mercury; (2) coarse ore, containing about thirty-five hundredths of 1 per cent of mercury; and (3) fine ore, containing sixty-five hundredths of 1 per cent of mercury. In recent years the annual average content of the concentrated ore treated in the furnaces has varied from seventy-five hundredths of 1 per cent to 1 per cent of mercury.

In Russia, the entire output of quicksilver is obtained from the mines of A. Auerbach & Co., situated near Nikitovka, on the Kursk-Kharkov Railroad, government of Ekaterinoslav, in the southern part of European Russia. In ancient times these deposits were exploited by the Greeks, but the present industry was not inaugurated until 1883. The average content of mercury in the ores extracted approximates four-tenths of 1 per cent.

In Italy, the important quicksilver producers are the Castelazara and Ripa mines in the Monte Amiata district, and the Vallalta mine in the province of Venice. The mines at Monte Amiata were originally worked by the Etruscans, and active operations are on record for the period from 1000 to 1200 A. D. The present industry began at Siele in 1846 and at Carnucchi in 1879. The ores average from three-tenths to six-tenths of 1 per cent of mercury and are treated in furnaces of modern construction. A detailed description of the furnace practice at Monte Amiata is published in The Mineral Industry, Vol. VI, pages 576 to 582.

In Mexico, the principal quicksilver producers are the Huitzuco mines, 50 miles north of Tixtla, in the state of Guerrero, and the mines at Guadalcazar. The Huitzuco deposits were first exploited in 1874 and since 1885 they have contributed annually an output of from 2,000 to 3,000 flasks of quicksilver. The ores average from six-tenths of 1 per cent to 1 per cent of mercury, and the cost of labor and fuel is so small that ores averaging as low as three-tenths of 1 per cent of the metal can be treated profitably. The methods of mining and smelting are very primitive, and the amount of metal extracted by the furnace treatment rarely exceeds one-half of the quantity present in the ore. The mines at Guadalcazar, 70 miles northeast of San Luis Potosi, have been worked by two concerns, the Compañía de Minas de Azogue de Guadalcazar and the Compañía de Nueva Potosí. The ores in this district, which contain an average of from 2 to 3.5 per cent of mercury, are smelted in a retort furnace provided with dust boxes, condensers, and a number of brick settling chambers equipped with baffle plates. The smelting process is primitive and wasteful, yet labor and fuel are so cheap that the operations are carried on with financial profit. The old mines, worked by the Nueva Potosi Company, are reported to contain immense bodies of easily accessible cinnabar ore, carrying an average of 1 per cent of mercury. The plant of this company is equipped with two 6-ton furnaces.

In China, Australia (New South Wales), Algeria (Taghit), Brazil, Peru, and Colombia deposits of cinnabar have been reported from time to time, but in general, because of the inaccessibility of the various districts in which the deposits are located, they still await development. A small output of quicksilver was obtained early in 1902 by an English company operating the cinnabar deposits in the province of Kweichau in southwestern China.

Table 8 shows in detail the statistics of the quicksilver industry for 1902.

TABLE 8.—*Detailed summary: 1902.*

Number of mines	41
Number of operators	[1] 37
Character of ownership:	
Individual	9
Firm	7
Incorporated company	21
Salaried officials, clerks, etc.:	
Total number	117
Total salaries	$154,154
General officers—	
Number	16
Salaries	$29,650
Superintendents, managers, foremen, surveyors, etc.—	
Number	54
Salaries	$85,634
Foremen below ground—	
Number	20
Salaries	$20,220
Clerks—	
Number	27
Salaries	$18,650
Wage-earners:	
Aggregate average number	1,329
Aggregate wages	$881,340
Above ground—	
Total average number	472
Total wages	$329,980
Engineers, firemen, and other mechanics—	
Average number	139
Wages	$113,458
Miners—	
Average number	81
Wages	$46,217
Boys under 16 years—	
Average number	4
Wages	$1,145
All other wage-earners—	
Average number	248
Wages	$169,160
Below ground—	
Total average number	857
Total wages	$551,360
Miners—	
Average number	533
Wages	$382,526
Miners' helpers—	
Average number	226
Wages	$124,464
Boys under 16 years—	
Average number	4
Wages	$620
All other wage-earners [2]—	
Average number	94
Wages	$43,750
Average number of wage-earners at specified daily rates of pay:	
Engineers—	
$2.00 to $2.24	2
$2.25 to $2.49	7
$2.50 to $2.74	18
$2.75 to $2.99	5
$3.00 to $3.24	6
Firemen—	
$1.50 to $1.74	3
$1.75 to $1.99	4
$2.00 to $2.24	9
$2.25 to $2.49	15
$2.50 to $2.74	11
Machinists, blacksmiths, carpenters, and other mechanics—	
$1.25 to $1.49	1
$1.50 to $1.74	5
$1.75 to $1.99	1

[1] Includes operators distributed as follows: California, 34 (36 mines); Texas, 3 (5 mines).
[2] Includes timbermen and track layers.

TABLE 8.—*Detailed summary: 1902*—Continued.

Average number of wage-earners at specified daily rates of pay—Con.	
Machinists, blacksmiths, carpenters, and other mechanics—Con.	
$2.00 to $2.24	8
$2.25 to $2.49	11
$2.50 to $2.74	12
$2.75 to $2.99	3
$3.00 to $3.24	15
$3.25 to $3.49	2
$3.50 to $3.74	1
Miners—	
$1.00 to $1.24	32
$1.25 to $1.49	105
$1.50 to $1.74	14
$1.75 to $1.99	94
$2.00 to $2.24	20
$2.25 to $2.49	77
$2.50 to $2.74	219
$2.75 to $2.99	3
$3.00 to $3.24	48
$3.25 to $3.49	2
Miners' helpers—	
$0.75 to $0.99	1
$1.00 to $1.24	50
$1.25 to $1.49	62
$1.50 to $1.74	1
$1.75 to $1.99	52
$2.00 to $2.24	24
$2.25 to $2.49	22
$2.50 to $2.74	11
$2.75 to $2.99	3
Timbermen and track layers—	
$1.50 to $1.74	6
$2.00 to $2.24	11
$3.00 to $3.24	7
Boys under 16 years—	
Less than $0.50	2
$0.50 to $0.74	5
$1.00 to $1.24	1
All other wage-earners—	
$0.50 to $0.74	17
$0.75 to $0.99	9
$1.00 to $1.24	30
$1.25 to $1.49	43
$1.50 to $1.74	27
$1.75 to $1.99	13
$2.00 to $2.24	121
$2.25 to $2.49	28
$2.50 to $2.74	28
$3.00 to $3.24	2
Average number of wage-earners employed during each month:	
Men 16 years and over—	
January	1,335
February	1,326
March	1,324
April	1,335
May	1,322
June	1,300
July	1,289
August	1,291
September	1,319
October	1,325
November	1,351
December	1,335
Boys under 16 years—	
January	7
February	7
March	7
April	7
May	7
June	7
July	14
August	12
September	7
October	7
November	7
December	7
Contract work:	
Amount paid	$23,164
Number of employees	80
Miscellaneous expenses:	
Total	$59,767
Royalties and rent of mine and mining plant	$7,078
Rent of offices, taxes, insurance, interest, and other sundries.	$52,689
Cost of supplies and materials	$322,267
Product:	
Total value	$1,550,090
Quicksilver—	
Quantity, flasks	34,291
Value	$1,467,848
Cinnabar—	
Quantity, short tons	11,727
Value	$82,242
Power owned:	
Total horsepower	1,808
Engines—	
Steam—	
Number	56
Horsepower	1,574
Gas or gasoline—	
Number	17
Horsepower	152
Water wheels—	
Number	3
Horsepower	22
Other power—	
Number	5
Horsepower	60
Electric motors—	
Number	3
Horsepower	15

PLATINUM

PLATINUM.

By David T. Day, Ph. D.

Occurrence.—At the time of the Eleventh Census platinum was known to occur in the United States in the following localities: California—Butte, Del Norte, Humboldt, Mendocino, Plumas, Sierra, and Trinity counties; Idaho—Wood river country; New York—near Plattsburg; North Carolina—Burke and Rutherford counties; and Oregon—Coos, Curry, Josephine, and Lane counties. In addition to these localities in the United States, there was a platinum product greater than that from the United States which helped to supply the American market from the region of Granite creek, British Columbia, and the copper ores from the Sudbury district of Canada also brought in some platinum and palladium in the nickel-copper matte imported into the United States.

Associated with these platinum ores were occasionally found the allied metals—osmium, iridium, and palladium.

About 1898 the demand for platinum became more considerable and the search for it, and especially for the allied metal osmium, became vigorous. It resulted in much prospecting in the Eastern states, as well as in the West, and many assays of supposed platinum ores, made by Mr. A. W. Johnston,[1] showed that certain rocks in eastern Pennsylvania, eastern New York, and in many other localities contained traces of platinum.

The one event of importance in the development of the platinum industry in the United States was the discovery by Dr. L. D. Godshall, manager of the Boston and Wyoming Smelter, at Encampment,[2] that the copper ores and matte of the Rambler mine, Grand Encampment district of Wyoming, contained platinum and palladium. These observations were confirmed by Professors Wells and Penfield, of Yale University,[3] who separated sperrylite (platinum diarsenide) from this Rambler ore. Further investigations by Mr. Johnston and Professor Kemp showed that the ore of the Rambler mine contains platinum intimately mixed with all the copper ores and even the chalcopyrite, which apparently was the original copper ore in this mine, also contains platinum. This confirms an observation of the writer in 1899 to the effect that platinum occurs in the pyrite grains found in certain hydraulic mines on the Trinity river in California, notably in the mine of Mr. F. Huertevant. These observations have led the searchers for platinum to examine a great many deposits of pyrite in the United States with the hope of finding them commercially rich in platinum, however, without commercial result, so far as the writer is informed. This work is referred to, however, as indicating a direction of search for platinum which may yet prove profitable.

At the time of the Twelfth Census, therefore, the supply of platinum to the United States market, in addition to the importations from Russia and small importations from South America, consisted in the supply of platinum obtained from the localities in California and Oregon mentioned above, a small product from the Granite creek district, British Columbia, and a more considerable product obtained in refining the nickel-copper matte from the Sudbury district of Canada. The platinum deposits of Russia, which afford the principal supply of the world, have lately been described by Mr. Chester V. Purington in the Engineering and Mining Journal, Vol. LXXVII, page 720. A complete description of the occurrence of platinum in all parts of the world is given by Prof. J. F. Kemp, of Columbia College, New York, in Bulletin 193, United States Geological Survey.

The writer made an investigation in 1899 as to the proportions of platinum, osmium, and iridosmium present with gold in various parts of the West, and, supplementary to this, Dr. Waldron Shapleigh determined the proportion of osmium to platinum in many of the same samples, the results of which are given in the following statement:[4]

[1] James F. Kemp, United States Geological Survey, Bulletin 193, pages 31 and 33.
[2] Engineering and Mining Journal, Vol. LXII, page 843.
[3] American Journal of Science, fourth series, Vol. 13, 1902, page 95.
[4] Transactions of the American Institute of Mining Engineers, Vol. XXX, page 708.

		Highest per cent.	Lowest per cent.
Beegum district, Shasta county, Cal.	Platinum	20.0	13.5
	Other platinum metals[1]	84.0	79.0
Hayfork district, Trinity county, Cal.	Platinum	73.0	30.0
	Other platinum metals	58.0	18.0
Trinity river district, Trinity county, Cal.	Platinum	27.0	15.0
	Other platinum metals	80.0	72.0
Crescent City, Del Norte county, Cal.	Platinum	11.0	8.0
	Other platinum metals	83.0	46.0
Port Orford, Curry county, Oreg.	Platinum	47.0	15.0
	Other platinum metals	83.0	23.0

[1] The "other platinum metals" include iridium, osmium, ruthenium, rhodium, and palladium.

Production.—From the domestic ores in the United States the product during 1902 was 94 ounces, valued at $1,814. This was obtained as a side product in placer gold mining, and as the production is entirely dependent upon the more important production of gold this great decrease in the quantity of the platinum produced, as compared with 1,408 ounces in 1901, is easily understood. In fact, the product during the last few years has varied most widely both in quantity and in the value of the product. The variation in value has been due not only to the real fluctuation and gradual increase in the price of refined platinum, but particularly to the fact that the value given has been that of the crude grains as collected and which vary widely in their contents of pure platinum. In addition to the platinum product of 1902, 20 fine ounces of iridium were obtained. In 1901 the corresponding product was 253 ounces of iridium.

The production of platinum in previous years, as collected by the United States Geological Survey, is quoted in the following table:

TABLE 1.—*Production of crude platinum in the United States, 1880 to 1900, and of refined metal from domestic ores in 1901 and 1902.*[1]

YEAR.	Quantity (ounces).	Value.	YEAR.	Quantity (ounces).	Value.
1880	100	$400	1892	80	$550
1881	100	400	1893	75	517
1882	200	600	1894	100	600
1883	200	600	1895	150	900
1884	150	450	1896	163	944
1885	250	187	1897	150	900
1886	50	100	1898	225	3,875
1887	448	1,838	1899	300	1,800
1888	500	2,000	1900	400	2,500
1889	500	2,000	1901	1,408	27,526
1890	600	2,500	1902	94	1,874
1891	100	500			

[1] The chief variations in price have been due to the quality of the crude grains. In 1901 and 1902, however, the average price for the refined metal has been given.

Of the total production of platinum in the world, about 90 per cent comes from Russia, with the remainder divided among Colombia, South America; New South Wales, Australia; the United States; and Canada. The average annual product in Russia, as is shown in the following table, was 104,023.6 ounces for the ten years 1881 to 1890, inclusive, and 183,376 ounces for the eleven years 1891 to 1901, inclusive.

TABLE 2.—*Production of platinum in Russia: 1824 to 1901.*

YEAR.	PRODUCTION.		
	Ounces.	Russian equivalent.	
		Poods.[1]	*Funts.*
1824	[2] 1,066	2	1
1825	[2] 6,116	11	24.5
1826 to 1830	[2] 168,345	319	26.25
1831 to 1835	[2] 290,103	550	34
1836 to 1840	[2] 238,142	452	7.5
1841 to 1845	[2] 311,079	590	27.25
1846 to 1850	[2] 12,347	23	17.75
1851 to 1855	[2] 48,088	91	12
1856 to 1860	[2] 72,058	136	33
1861 to 1865	[2] 232,487	441	18
1866 to 1870	[2] 315,908	599	34.25
1871 to 1875	[2] 279,955	531	23.25
1876 to 1880	[2] 340,265	646	4
1881 to 1885	[2] 496,182	942	6.25
1886 to 1890	[2] 544,054	1,033	2
1891	[2] 135,873	258	....
1892	[3] 147,459	280	....
1893	[3] 169,099	304	....
1894	[3] 163,258	310	....
1895	[3] 141,140	268	....
1896	[3] 156,412	297	....
1897	[3] 178,531	339	....
1898	[3] 192,750	366	....
1899	[3] 191,697	364	....
1900	[3] 163,258	310	....
1901	[3] 203,283	386	....

[1] The pood is estimated at 526.64 ounces.
[2] Taken from the Russian Journal of Financial Statistics, 1901.
[3] Taken from the Viestnik Finansov (Messenger of Finance), No. 50, 1903.

Prices.—Since the close of 1899 the price of platinum has steadily increased, reaching its maximum value in January, 1902, when the price in New York was $20 to $21 per ounce for ingot platinum. The price fell to $19.50 in February, and in June to $19, which price prevailed to the close of the year. Best hammered platinum was quoted as follows: January, 1902, 82 cents per gram; June, 76 cents; July, 74 cents; August, 73.5 cents; and December, 72.5 cents. Osmiridium is quoted at from $6 to $10 per ounce. This gradual increase in the price of platinum during the past ten years is due to the fact that there has been found no metal or alloy which will take the place of platinum, and also to the fact that there is such a limited supply and increased demand.

The price of platinum is practically determined by Johnson, Matthey & Co., of London, who are refiners of a large portion of the Russian output.

Imports.—The following table gives the imports of platinum into the United States from 1880 to 1902, as reported by the Bureau of Statistics:

TABLE 3.—*Platinum imported and entered for consumption in the United States: 1880 to 1902.*

CALENDAR YEARS, SINCE 1886; PREVIOUS YEARS END JUNE 30.	Manufactured (value).	UNMANUFACTURED.		Vases or retorts, etc. (value).
		Quantity.	Value.	
		Pounds.		
1880	$964	....	$217,144	$41,827
1881	290	....	278,343	21,292
1882	1,731	3,126	285,781	48,452
1883	4	3,104	298,799	92,967
1884	....	2,846	289,808	83,112
1885	3	2,612	285,239	17,473
1886	....	3,422	373,941	71,861
1887	....	4,732	509,414	68,051
1888	....	5,226	558,920	58,355
1889	338	5,394	555,742	110,757
1890	....	5,763	996,886	77,957
1891	....	3,416	621,776	46,814
1892	....	5,419	565,476	60,210
1893	....	4,275	534,235	56,592
1894	....	4,099	485,272	88,195
1895	171	5,117	690,584	27,354
1896	....	5,558	906,671	106,286
1897	121	5,698	958,368	47,897
1898	271	6,703	1,179,242	52,012
1899	876	6,674	1,482,157	54,877
1900	827	7,372	1,726,206	35,887
1901	2,513	6,220	1,671,418	21,969
1902	2,705	7,346	1,950,362	34,913